US009402066B2

(12) **United States Patent**
Jeong et al.

(10) **Patent No.: US 9,402,066 B2**
(45) **Date of Patent: Jul. 26, 2016**

(54) **METHOD AND DEVICE FOR ENCODING A DEPTH MAP OF MULTI VIEWPOINT VIDEO DATA, AND METHOD AND DEVICE FOR DECODING THE ENCODED DEPTH MAP**

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(73) Assignee: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 289 days.

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(22) PCT Filed: **Aug. 9, 2012**

(86) PCT No.: **PCT/KR2012/006357**

§ 371 (c)(1),
(2), (4) Date: **Feb. 10, 2014**

(87) PCT Pub. No.: **WO2013/022297**

PCT Pub. Date: **Feb. 14, 2013**

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Related U.S. Application Data

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(51) **Int. Cl.**
H04N 15/00 (2006.01)
H04N 13/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04N 13/0048*** (2013.01); ***H04N 19/597*** (2014.11); ***H04N 19/96*** (2014.11); *H04N 2213/005* (2013.01)

(58) **Field of Classification Search**
USPC 348/43, 44, 42, 47, 48, 51, 52, 59, 348/14.07, 208.99, 239, 382, 393.1, 394.1, 348/395.1, 401.1, 420.1, 421.1, 429.1, 468, 348/564, 568, 588, 608, 642, 840; 375/240.01, 240.03, 240.07, 240.08, 375/240.12, 240.13, 240.15, 240.16, 375/240.24, 240.26, 240.27
See application file for complete search history.

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Primary Examiner — Brian P. Yenke
Assistant Examiner — Mustafizur Rahman
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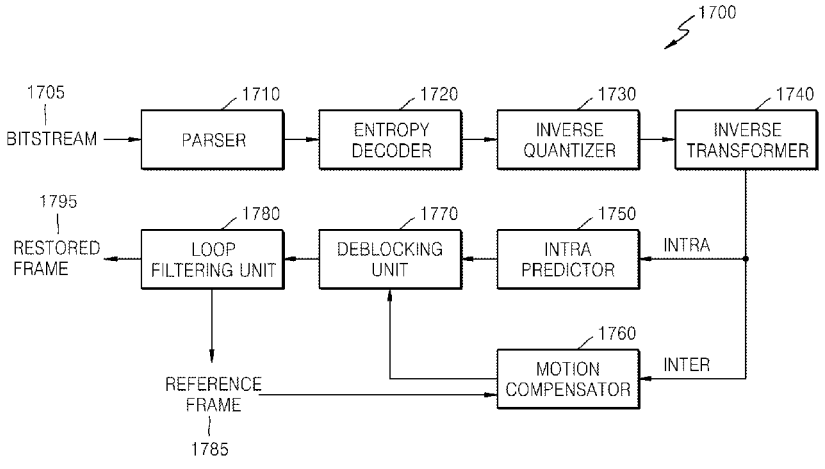
(57) **ABSTRACT**

A method and apparatus for decoding the depth map of multi-view video data are provided. The method includes splitting a block of restored multi-view color video frame into a partition based on a pixel value of the block of the prediction-encoded and restored multi-view color video frame; obtaining a parameter indicating correlation between block partitions of the multi-view color video frame and block partitions of the depth map frame using peripheral pixel values of the block partitions of the multi-view color video frame and peripheral pixel values of the block partitions of the depth map frame corresponding to the block partitions of the multi-view color video frame with respect to each of the block partitions of the restored multi-view color video frame; and obtaining prediction values of corresponding block partitions of the depth map frame from the block partitions of the restored multi-view color video frame using the obtained parameter.

15 Claims, 28 Drawing Sheets



(51) **Int. Cl.**
H04N 19/597 (2014.01)
H04N 19/96 (2014.01)

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FIG. 1

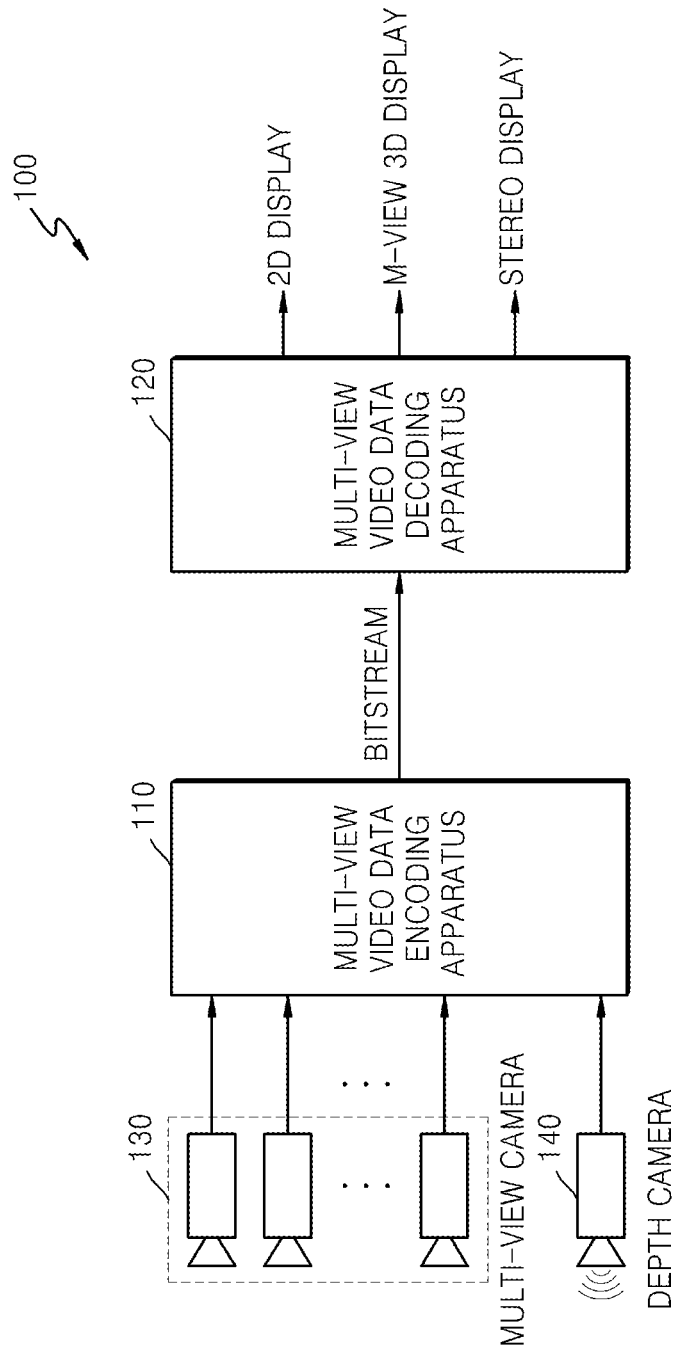

100
2D DISPLAY
M-VIEW 3D DISPLAY
STEREO DISPLAY
120
MULTI-VIEW VIDEO DATA DECODING APPARATUS
BITSTREAM
110
MULTI-VIEW VIDEO DATA ENCODING APPARATUS
130
MULTI-VIEW CAMERA
140
DEPTH CAMERA

FIG. 2

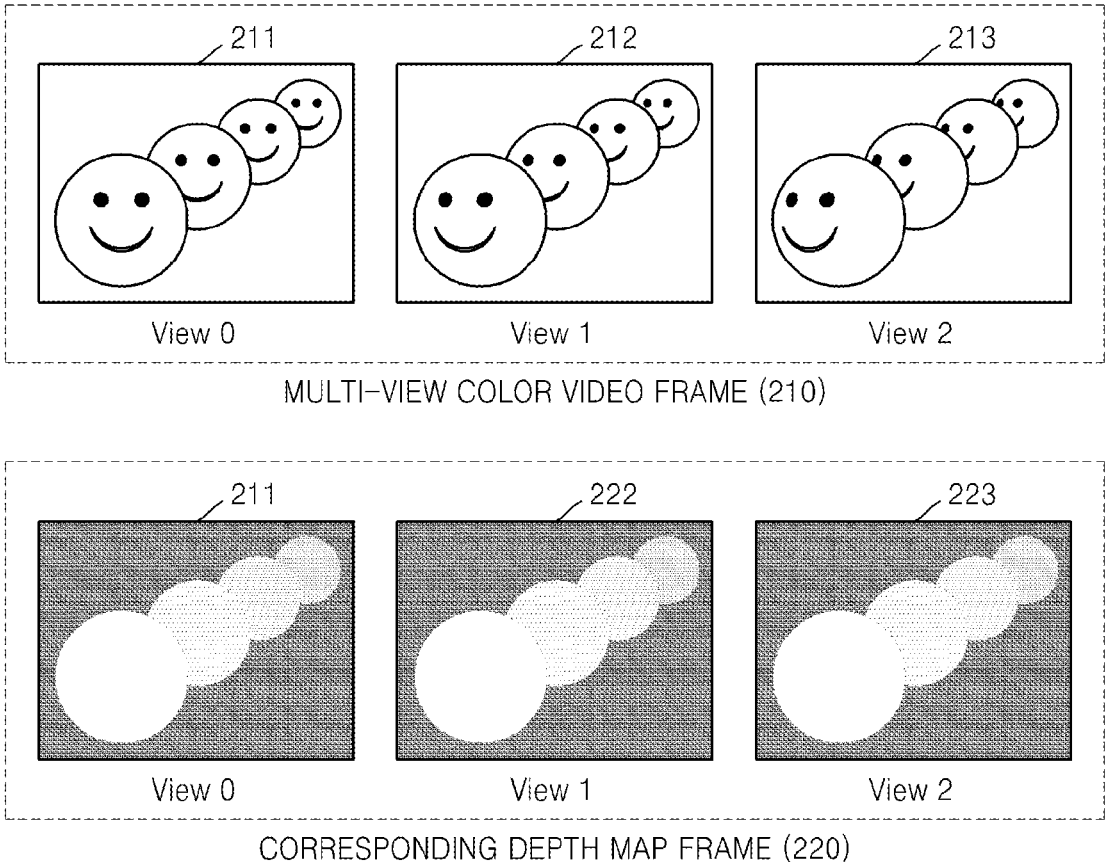

211
212
213
View 0
View 1
View 2
MULTI-VIEW COLOR VIDEO FRAME (210)
211
222
223
View 0
View 1
View 2
CORRESPONDING DEPTH MAP FRAME (220)

FIG. 3

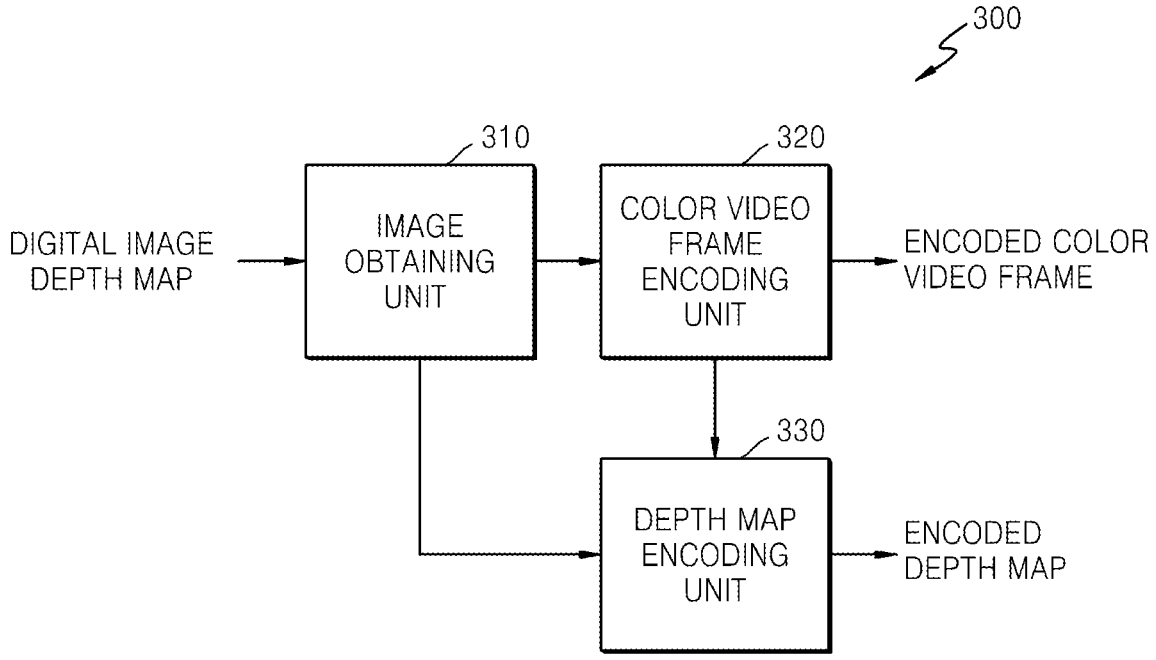

300
310
320
DIGITAL IMAGE
DEPTH MAP
IMAGE
OBTAINING
UNIT
COLOR VIDEO
FRAME
ENCODING
UNIT
ENCODED COLOR
VIDEO FRAME
330
DEPTH MAP
ENCODING
UNIT
ENCODED
DEPTH MAP

FIG. 4

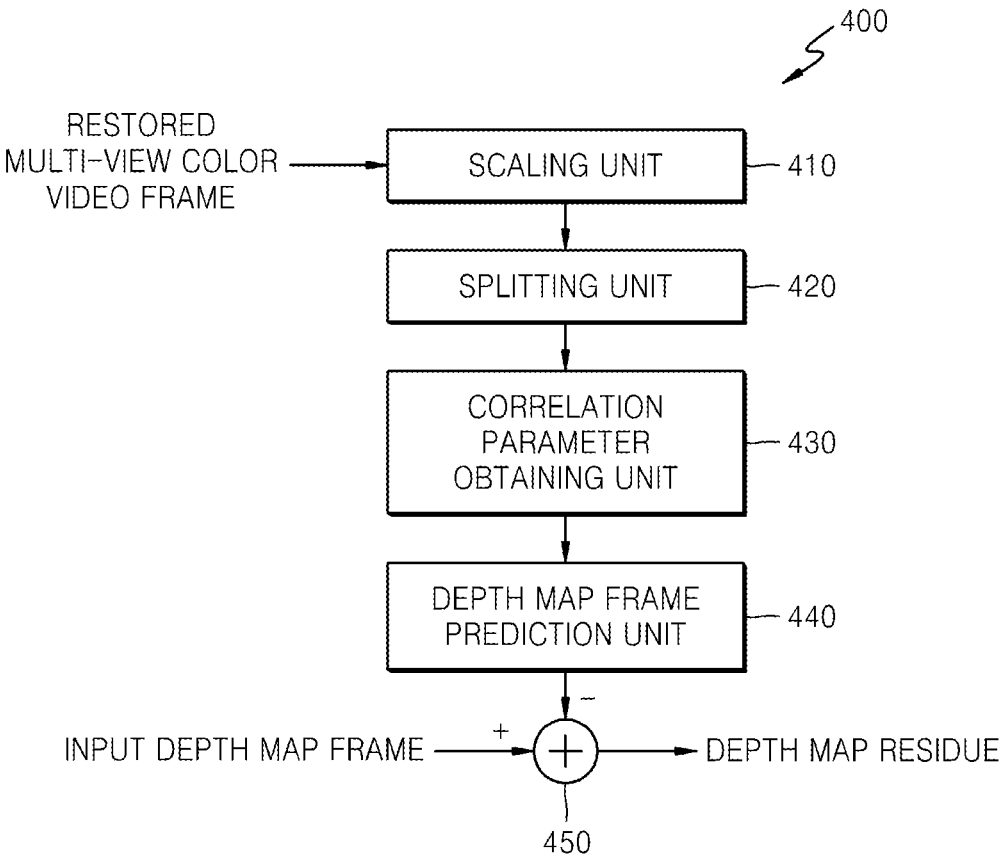

400
RESTORED MULTI-VIEW COLOR VIDEO FRAME
SCALING UNIT
410
SPLITTING UNIT
420
CORRELATION PARAMETER OBTAINING UNIT
430
DEPTH MAP FRAME PREDICTION UNIT
440
INPUT DEPTH MAP FRAME
+
−
DEPTH MAP RESIDUE
450

FIG. 5A

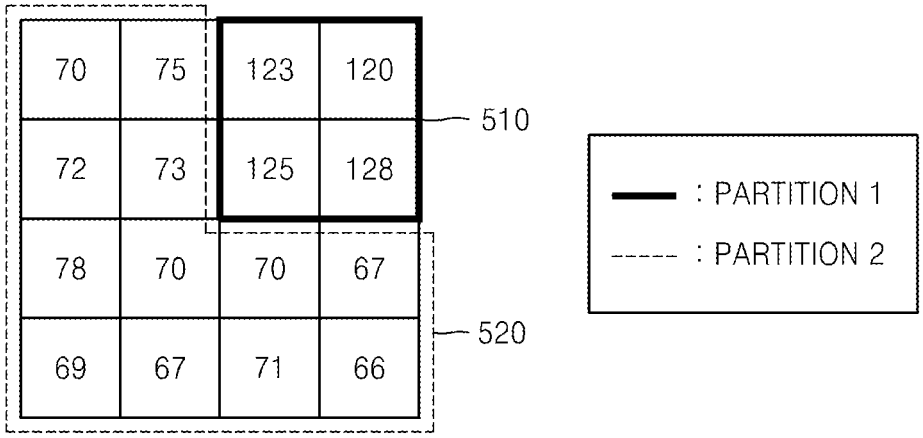

70
75
123
120
72
73
125
128
78
70
70
67
69
67
71
66
510
520
: PARTITION 1
: PARTITION 2

FIG. 5B

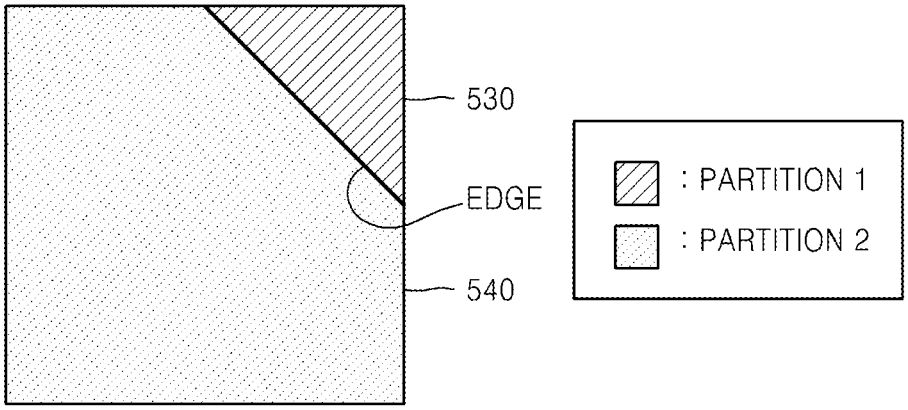

530
EDGE
540
: PARTITION 1
: PARTITION 2

FIG. 6

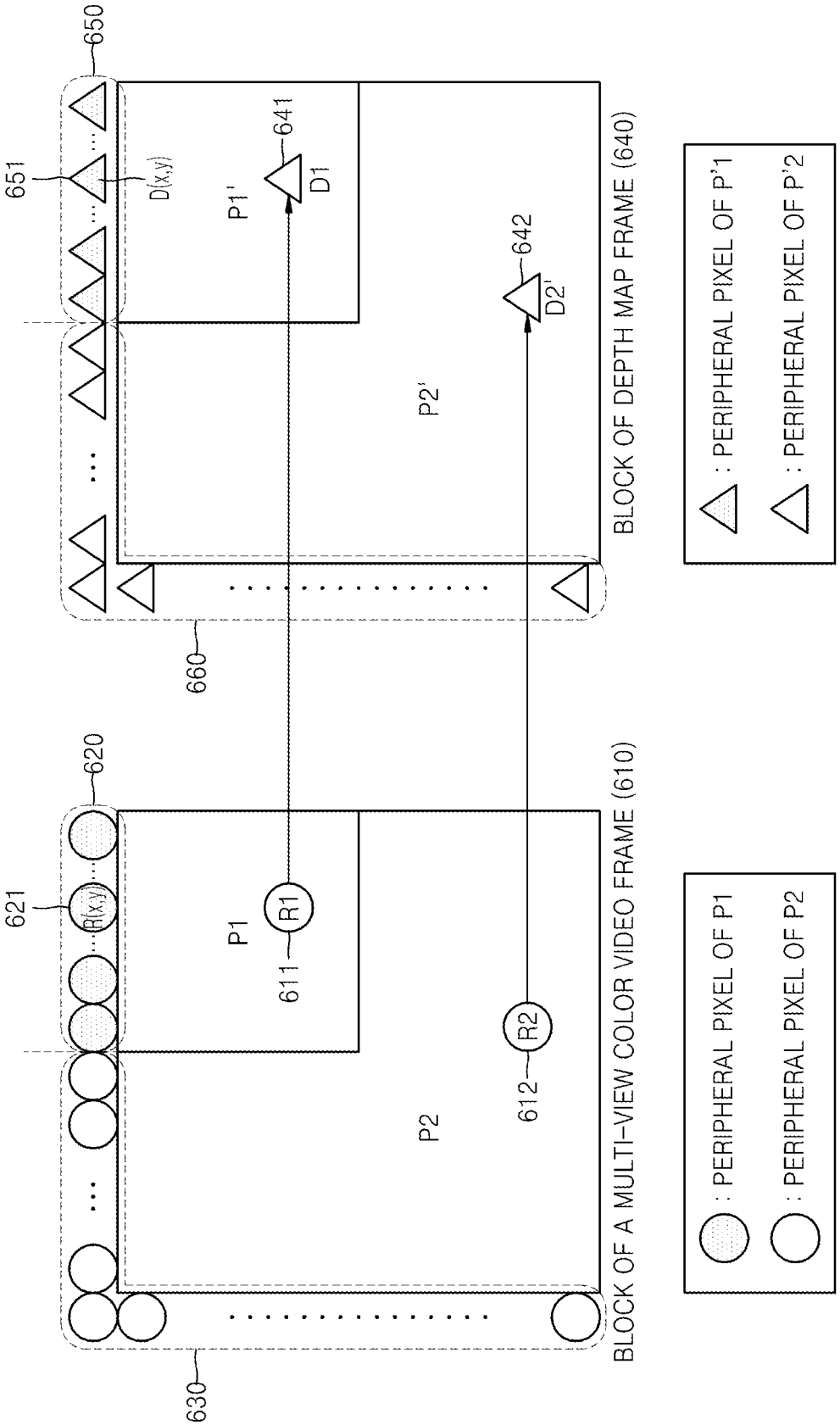

650
651
D(x,y)
641
D1
P1'
642
D2'
P2'
660
BLOCK OF DEPTH MAP FRAME (640)
620
621
R(x,y)
P1
R1
611
P2
R2
612
630
BLOCK OF A MULTI-VIEW COLOR VIDEO FRAME (610)
: PERIPHERAL PIXEL OF P'1
: PERIPHERAL PIXEL OF P'2
: PERIPHERAL PIXEL OF P1
: PERIPHERAL PIXEL OF P2

FIG. 7

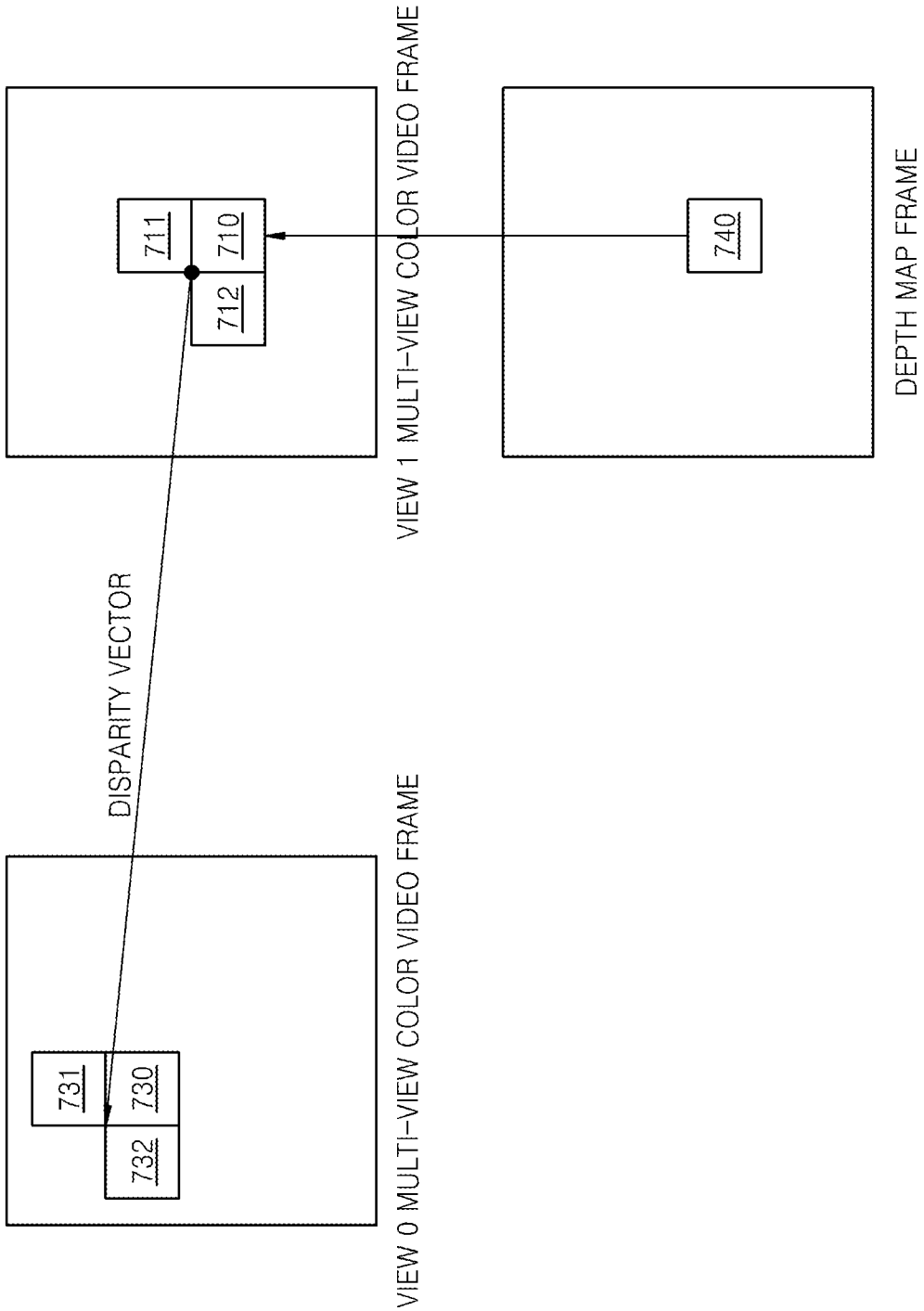

711
710
712
740
731
730
732
DISPARITY VECTOR
VIEW 1 MULTI-VIEW COLOR VIDEO FRAME
DEPTH MAP FRAME
VIEW 0 MULTI-VIEW COLOR VIDEO FRAME

FIG. 8

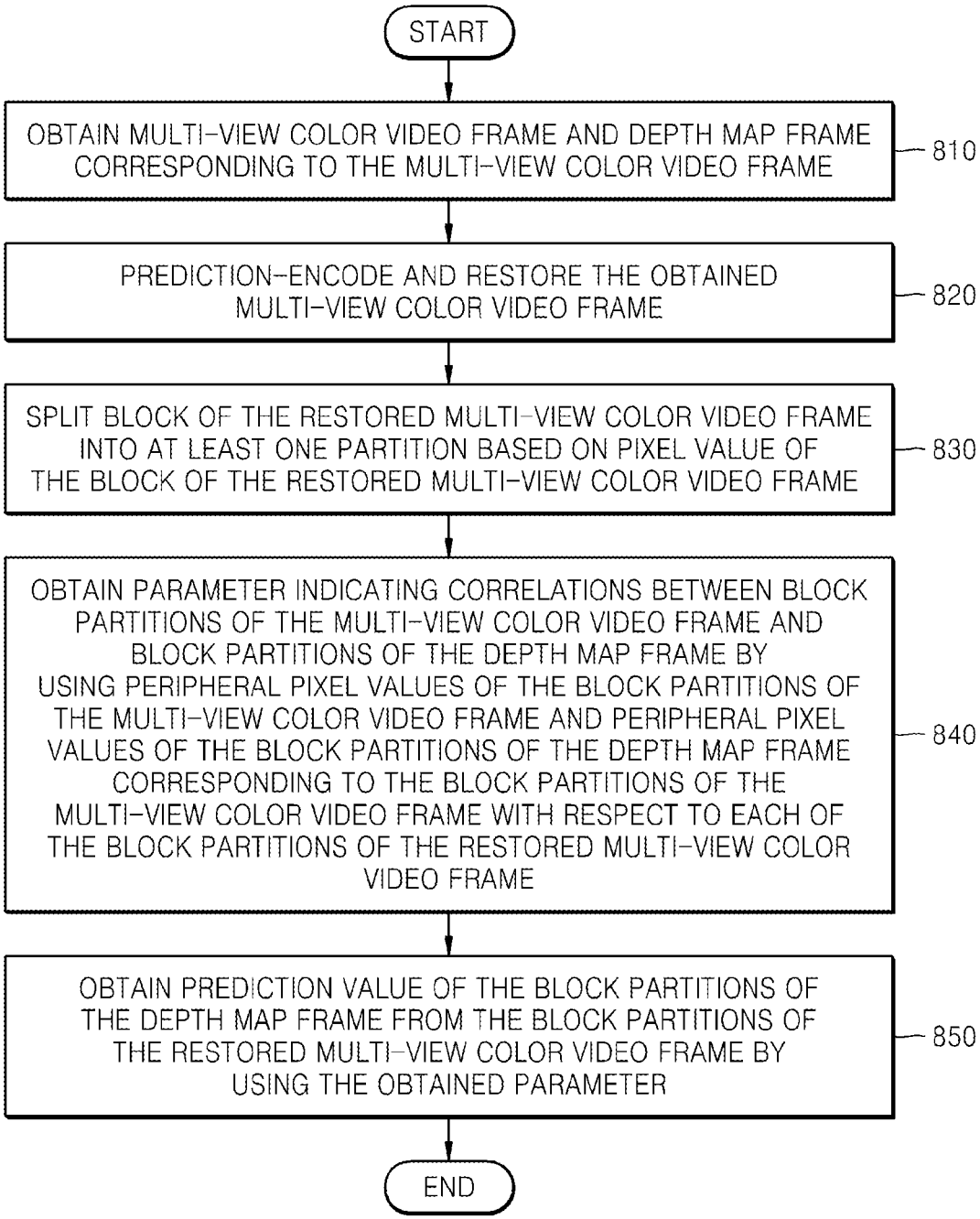

START
OBTAIN MULTI-VIEW COLOR VIDEO FRAME AND DEPTH MAP FRAME CORRESPONDING TO THE MULTI-VIEW COLOR VIDEO FRAME
810
PREDICTION-ENCODE AND RESTORE THE OBTAINED MULTI-VIEW COLOR VIDEO FRAME
820
SPLIT BLOCK OF THE RESTORED MULTI-VIEW COLOR VIDEO FRAME INTO AT LEAST ONE PARTITION BASED ON PIXEL VALUE OF THE BLOCK OF THE RESTORED MULTI-VIEW COLOR VIDEO FRAME
830
OBTAIN PARAMETER INDICATING CORRELATIONS BETWEEN BLOCK PARTITIONS OF THE MULTI-VIEW COLOR VIDEO FRAME AND BLOCK PARTITIONS OF THE DEPTH MAP FRAME BY USING PERIPHERAL PIXEL VALUES OF THE BLOCK PARTITIONS OF THE MULTI-VIEW COLOR VIDEO FRAME AND PERIPHERAL PIXEL VALUES OF THE BLOCK PARTITIONS OF THE DEPTH MAP FRAME CORRESPONDING TO THE BLOCK PARTITIONS OF THE MULTI-VIEW COLOR VIDEO FRAME WITH RESPECT TO EACH OF THE BLOCK PARTITIONS OF THE RESTORED MULTI-VIEW COLOR VIDEO FRAME
840
OBTAIN PREDICTION VALUE OF THE BLOCK PARTITIONS OF THE DEPTH MAP FRAME FROM THE BLOCK PARTITIONS OF THE RESTORED MULTI-VIEW COLOR VIDEO FRAME BY USING THE OBTAINED PARAMETER
850
END

FIG. 9

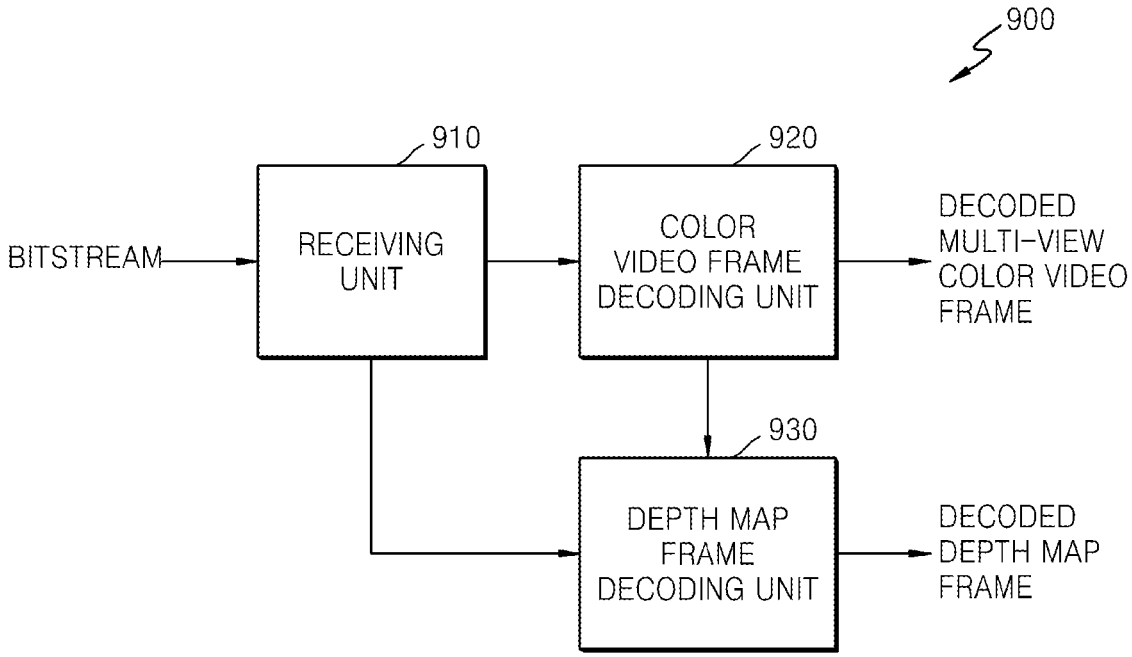

900
910
920
BITSTREAM
RECEIVING UNIT
COLOR VIDEO FRAME DECODING UNIT
DECODED MULTI-VIEW COLOR VIDEO FRAME
930
DEPTH MAP FRAME DECODING UNIT
DECODED DEPTH MAP FRAME

FIG. 10

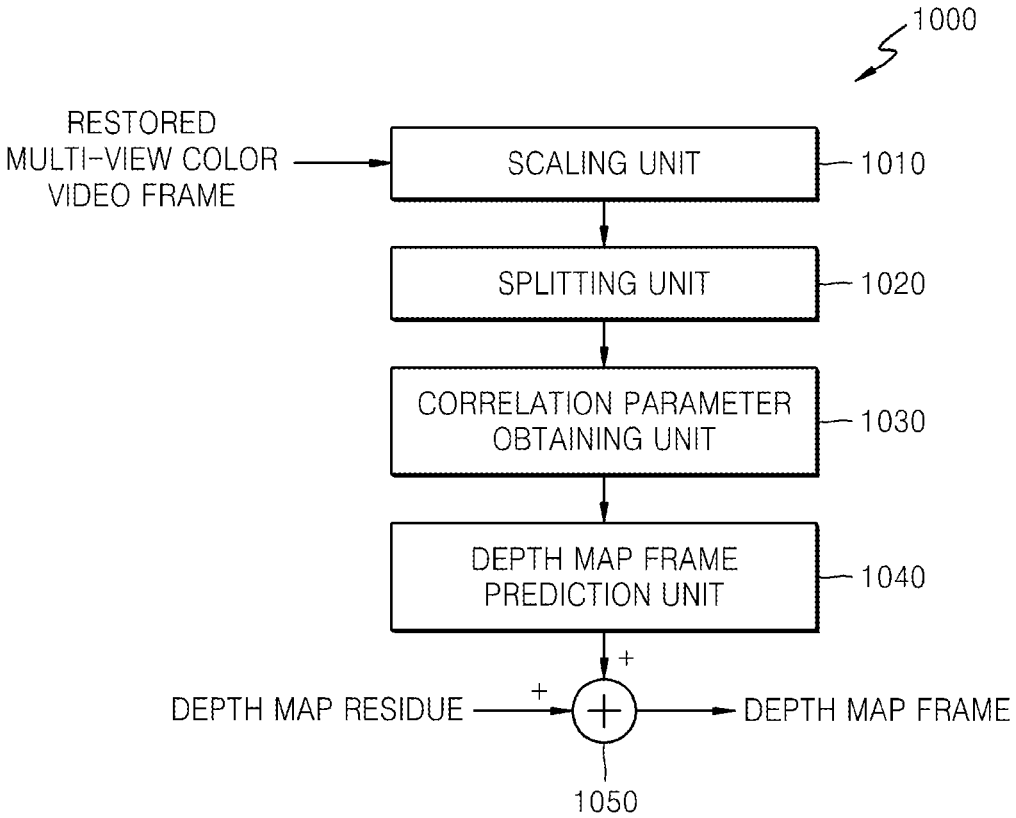

1000
RESTORED MULTI-VIEW COLOR VIDEO FRAME
SCALING UNIT
1010
SPLITTING UNIT
1020
CORRELATION PARAMETER OBTAINING UNIT
1030
DEPTH MAP FRAME PREDICTION UNIT
1040
+
+
DEPTH MAP RESIDUE
DEPTH MAP FRAME
1050

FIG. 11

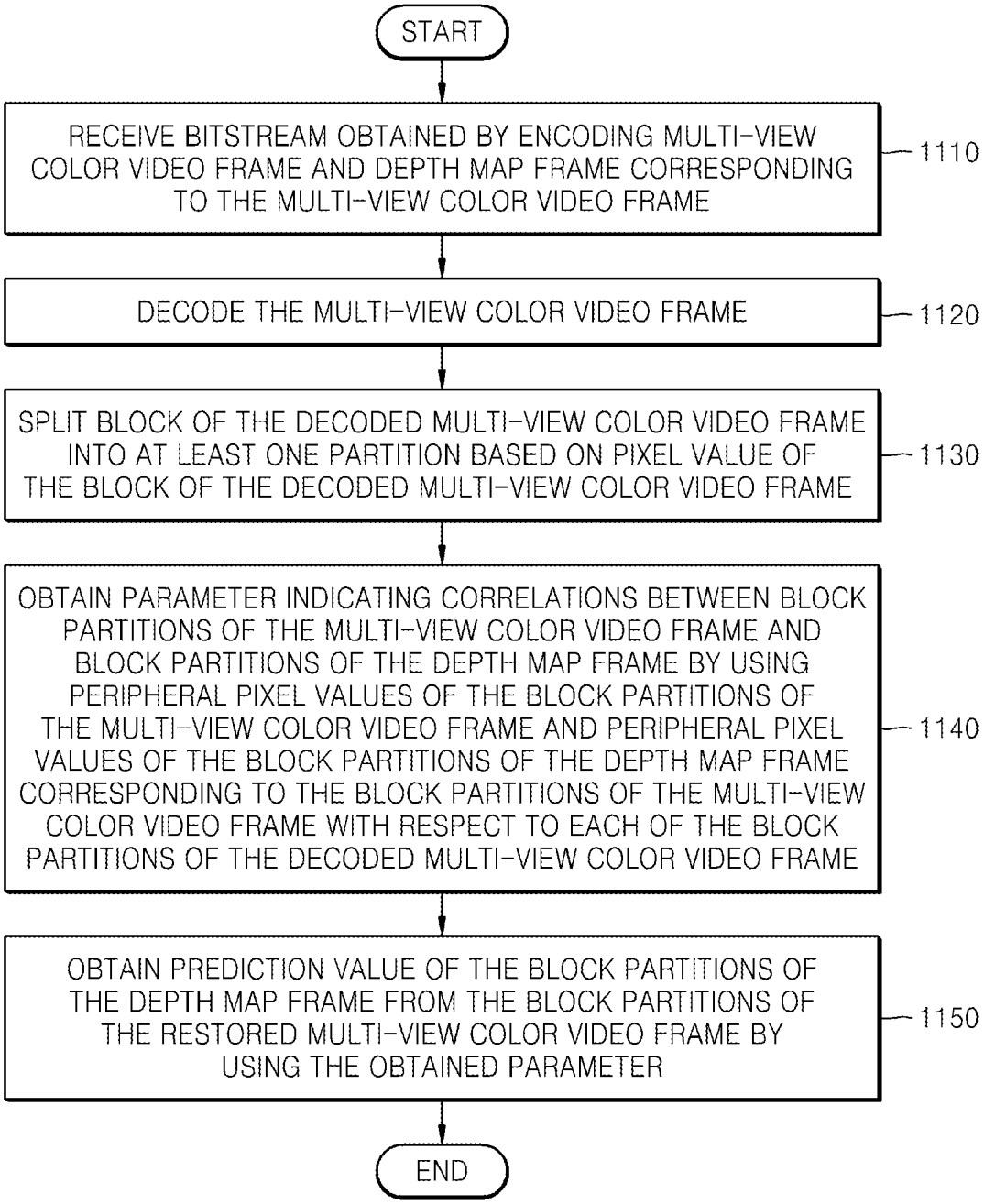

START
RECEIVE BITSTREAM OBTAINED BY ENCODING MULTI-VIEW COLOR VIDEO FRAME AND DEPTH MAP FRAME CORRESPONDING TO THE MULTI-VIEW COLOR VIDEO FRAME
1110
DECODE THE MULTI-VIEW COLOR VIDEO FRAME
1120
SPLIT BLOCK OF THE DECODED MULTI-VIEW COLOR VIDEO FRAME INTO AT LEAST ONE PARTITION BASED ON PIXEL VALUE OF THE BLOCK OF THE DECODED MULTI-VIEW COLOR VIDEO FRAME
1130
OBTAIN PARAMETER INDICATING CORRELATIONS BETWEEN BLOCK PARTITIONS OF THE MULTI-VIEW COLOR VIDEO FRAME AND BLOCK PARTITIONS OF THE DEPTH MAP FRAME BY USING PERIPHERAL PIXEL VALUES OF THE BLOCK PARTITIONS OF THE MULTI-VIEW COLOR VIDEO FRAME AND PERIPHERAL PIXEL VALUES OF THE BLOCK PARTITIONS OF THE DEPTH MAP FRAME CORRESPONDING TO THE BLOCK PARTITIONS OF THE MULTI-VIEW COLOR VIDEO FRAME WITH RESPECT TO EACH OF THE BLOCK PARTITIONS OF THE DECODED MULTI-VIEW COLOR VIDEO FRAME
1140
OBTAIN PREDICTION VALUE OF THE BLOCK PARTITIONS OF THE DEPTH MAP FRAME FROM THE BLOCK PARTITIONS OF THE RESTORED MULTI-VIEW COLOR VIDEO FRAME BY USING THE OBTAINED PARAMETER
1150
END

FIG. 12

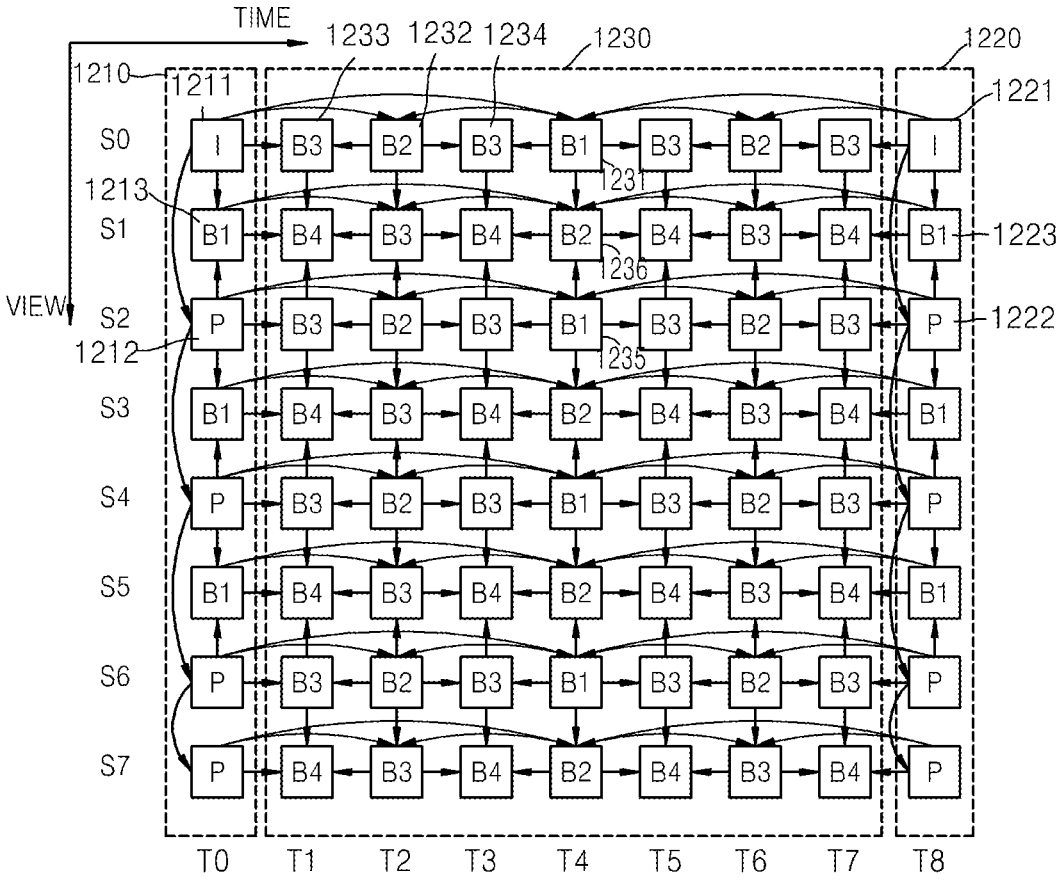

TIME
VIEW
1210
1211
1233
1232
1234
1230
1220
1221
1213
1212
1231
1236
1235
1223
1222
S0
S1
S2
S3
S4
S5
S6
S7
T0
T1
T2
T3
T4
T5
T6
T7
T8
I
P
B1
B2
B3
B4

FIG. 13

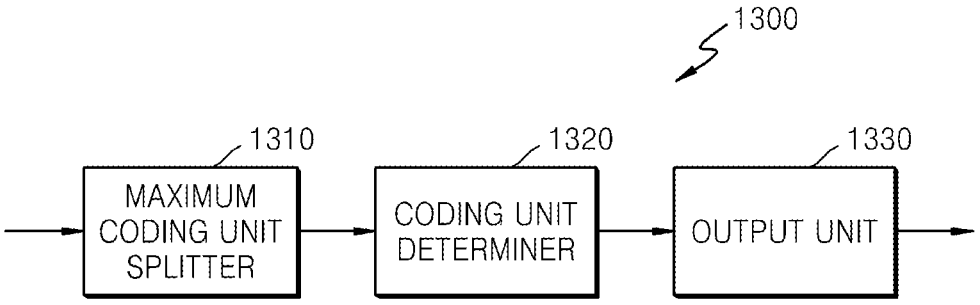

1300
1310
MAXIMUM CODING UNIT SPLITTER
1320
CODING UNIT DETERMINER
1330
OUTPUT UNIT

FIG. 14

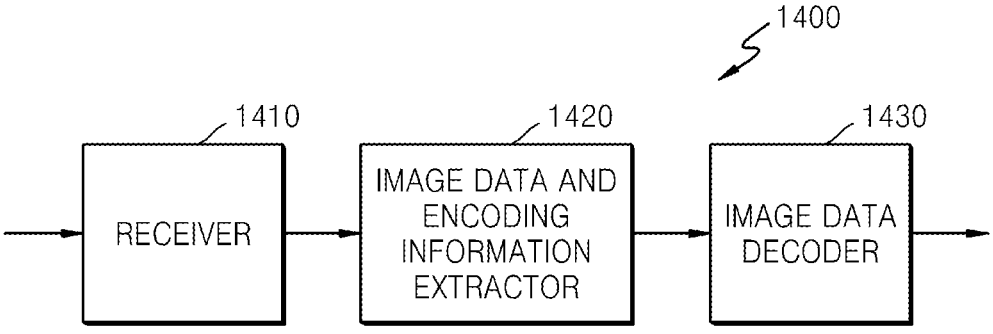

1400
1410
RECEIVER
1420
IMAGE DATA AND ENCODING INFORMATION EXTRACTOR
1430
IMAGE DATA DECODER

FIG. 15

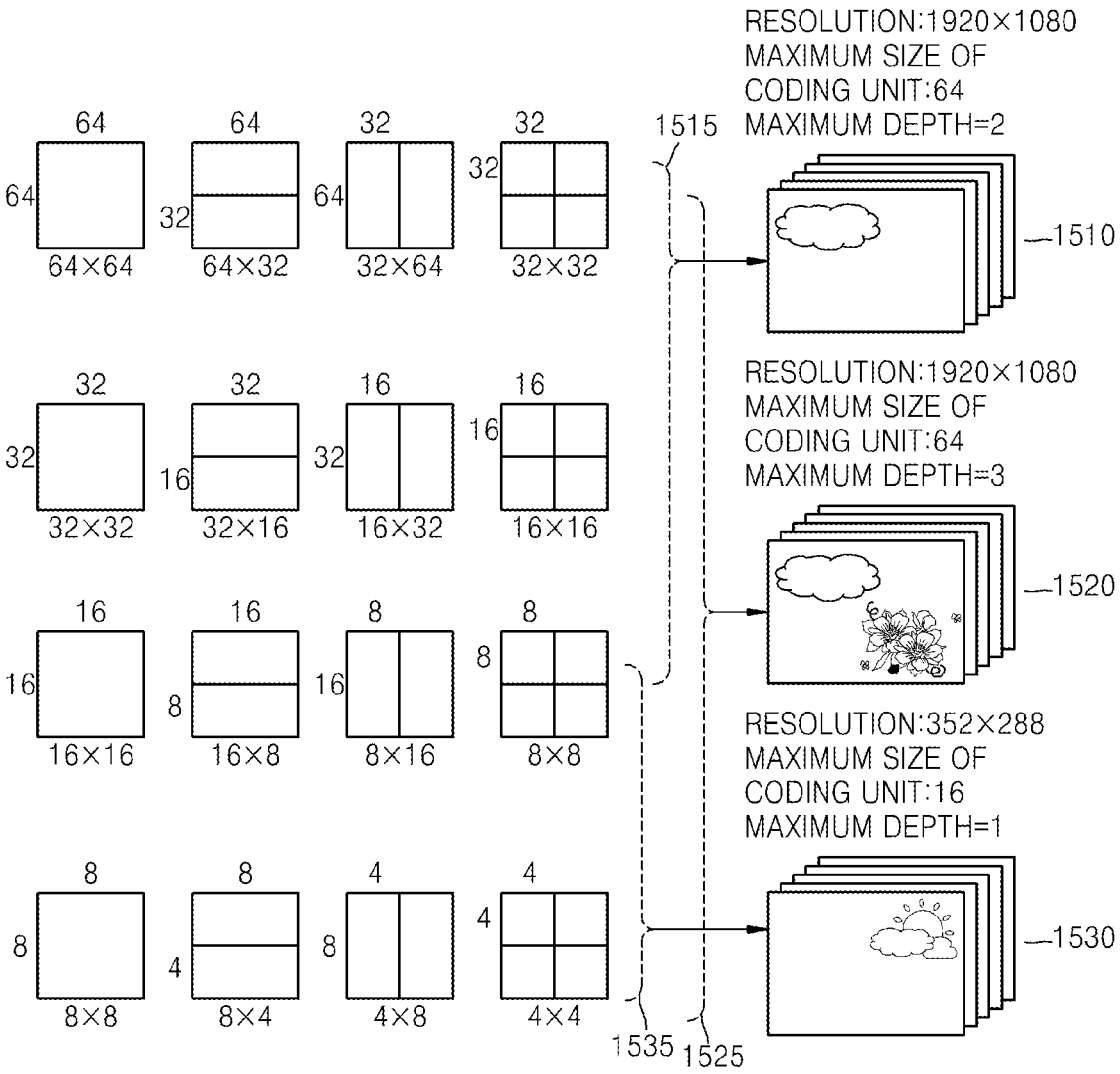

RESOLUTION:1920×1080
MAXIMUM SIZE OF
CODING UNIT:64
MAXIMUM DEPTH=2
1515
64
64
64×64
64
32
64×32
32
64
32×64
32
32
32×32
1510
RESOLUTION:1920×1080
MAXIMUM SIZE OF
CODING UNIT:64
MAXIMUM DEPTH=3
32
32
32×32
32
16
32×16
16
32
16×32
16
16
16×16
1520
RESOLUTION:352×288
MAXIMUM SIZE OF
CODING UNIT:16
MAXIMUM DEPTH=1
16
16
16×16
16
8
16×8
8
16
8×16
8
8
8×8
8
8
8×8
8
4
8×4
4
8
4×8
4
4
4×4
1530
1535
1525

FIG. 16

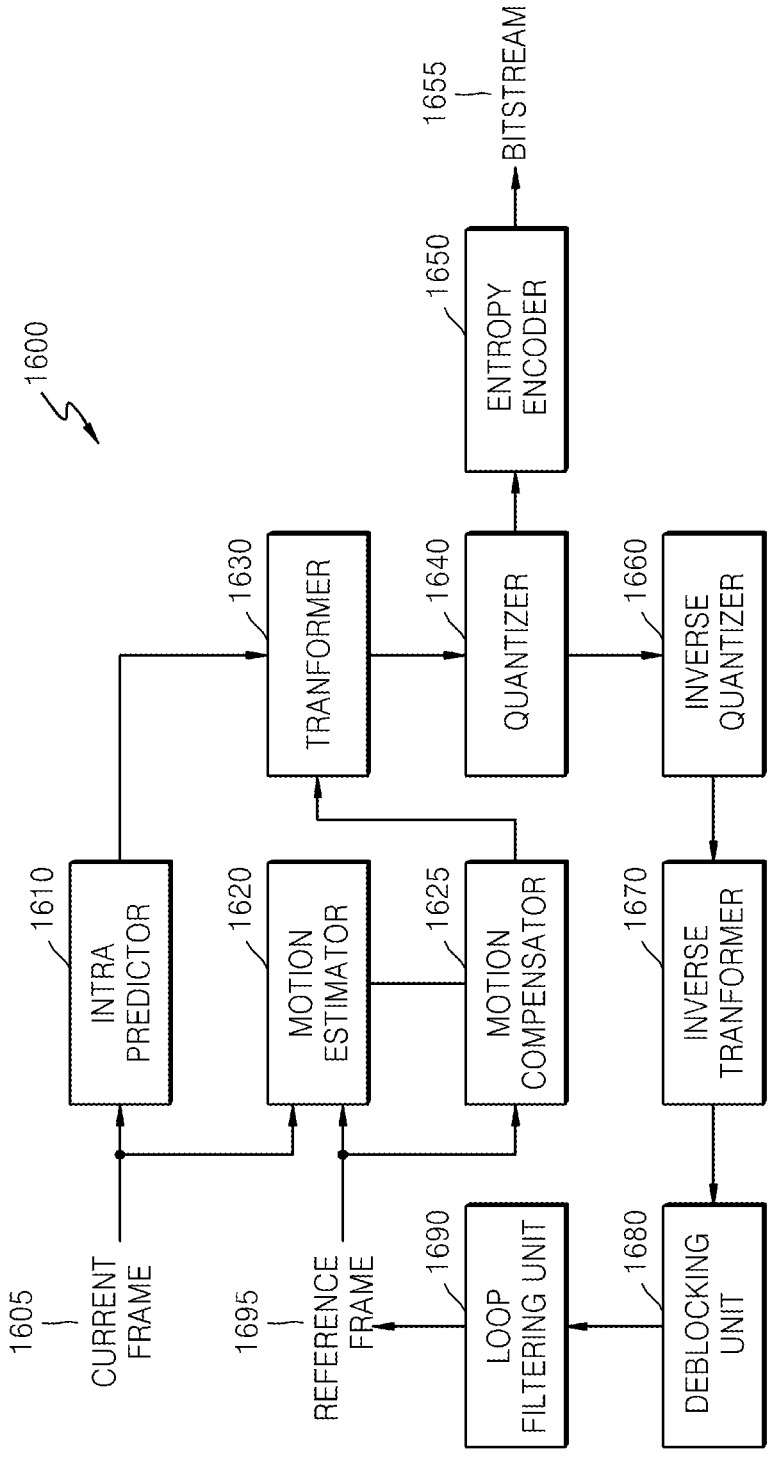

1600
1605
CURRENT FRAME
1610
INTRA PREDICTOR
1620
MOTION ESTIMATOR
1625
MOTION COMPENSATOR
1630
TRANFORMER
1640
QUANTIZER
1650
ENTROPY ENCODER
1655
BITSTREAM
1660
INVERSE QUANTIZER
1670
INVERSE TRANFORMER
1680
DEBLOCKING UNIT
1690
LOOP FILTERING UNIT
1695
REFERENCE FRAME

FIG. 17

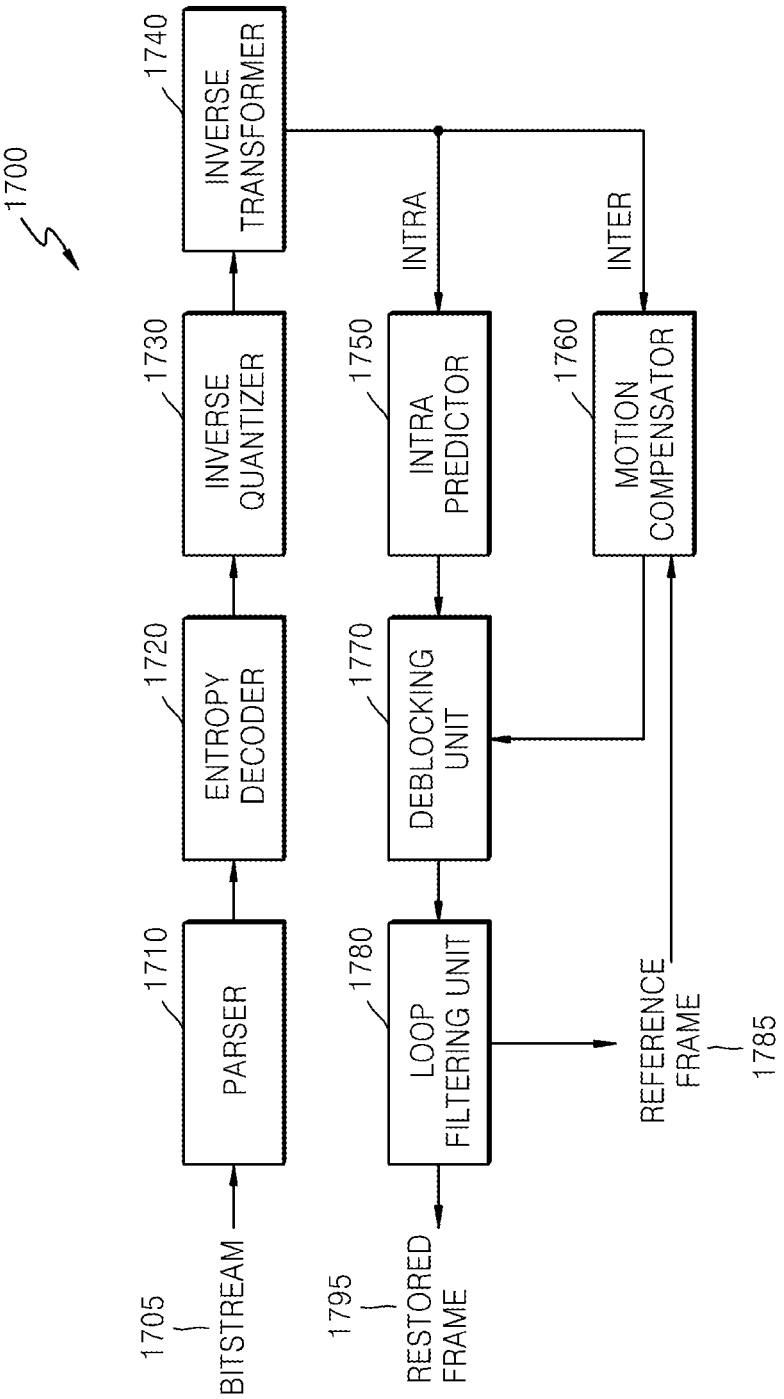

1700
1705
BITSTREAM
1710
PARSER
1720
ENTROPY DECODER
1730
INVERSE QUANTIZER
1740
INVERSE TRANSFORMER
INTRA
1750
INTRA PREDICTOR
INTER
1760
MOTION COMPENSATOR
1770
DEBLOCKING UNIT
1780
LOOP FILTERING UNIT
1785
REFERENCE FRAME
1795
RESTORED FRAME

FIG. 18

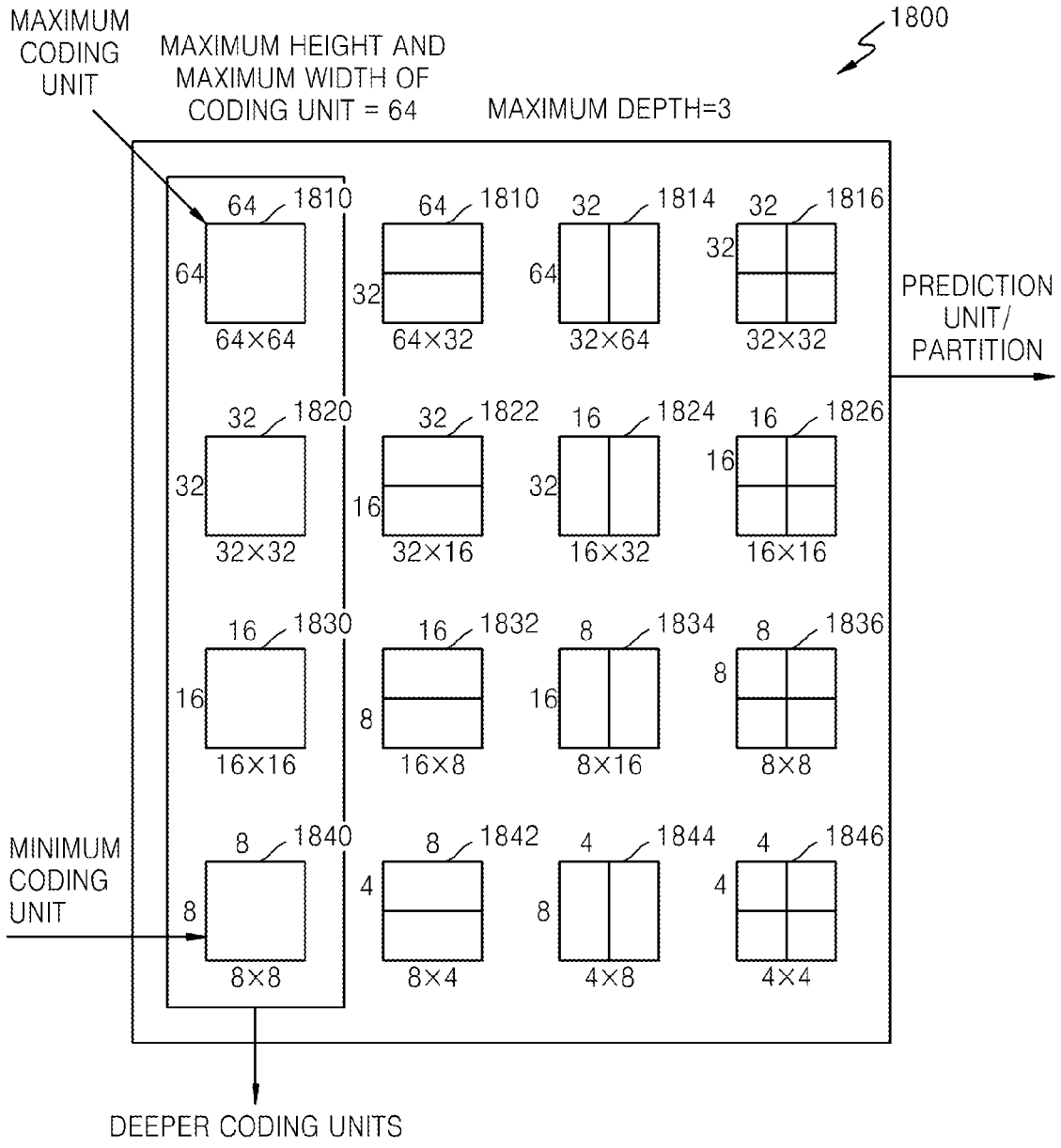

MAXIMUM CODING UNIT
MAXIMUM HEIGHT AND MAXIMUM WIDTH OF CODING UNIT = 64
MAXIMUM DEPTH=3
1800
64 1810
64×64
64 1810
64×32
32 1814
32×64
32 1816
32×32
PREDICTION UNIT/ PARTITION
32 1820
32×32
32 1822
32×16
16 1824
16×32
16 1826
16×16
16 1830
16×16
16 1832
16×8
8 1834
8×16
8 1836
8×8
MINIMUM CODING UNIT
8 1840
8×8
8 1842
8×4
4 1844
4×8
4 1846
4×4
DEEPER CODING UNITS

FIG. 19

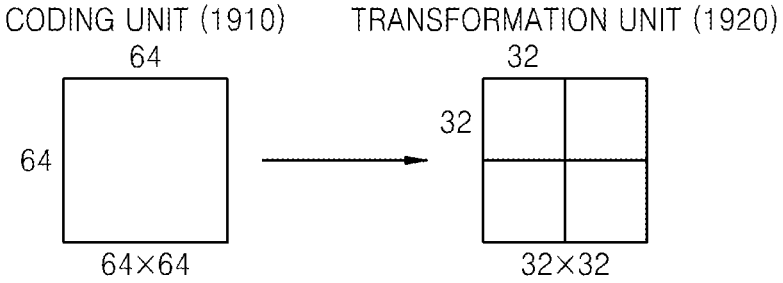
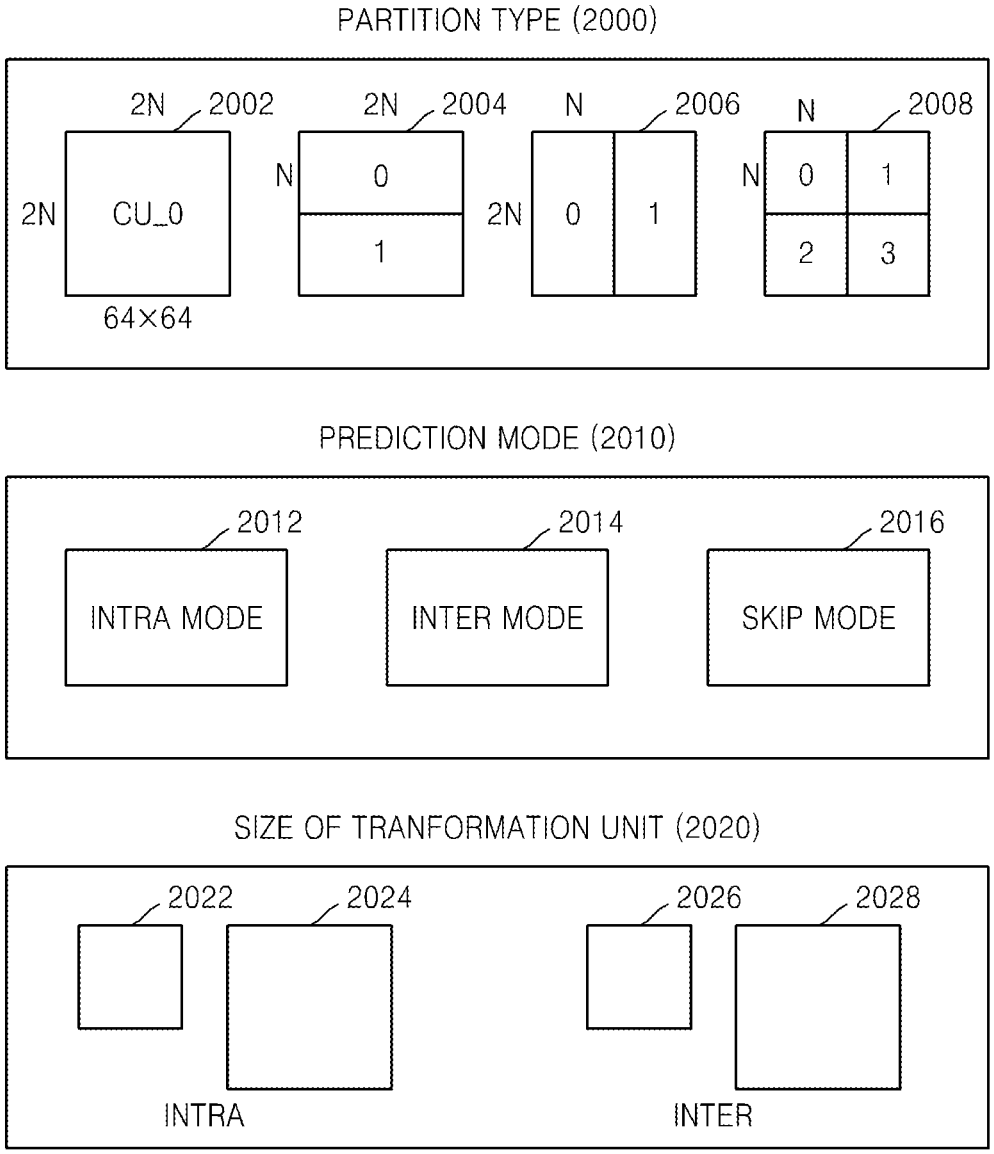

CODING UNIT (1910)
TRANSFORMATION UNIT (1920)
64
64
64×64
32
32
32×32

FIG. 20


PARTITION TYPE (2000)
2N
2002
2N
CU_0
64×64
2N
2004
N
0
1
N
2006
2N
0
1
N
2008
N
0
1
2
3
PREDICTION MODE (2010)
2012
INTRA MODE
2014
INTER MODE
2016
SKIP MODE
SIZE OF TRANFORMATION UNIT (2020)
2022
2024
INTRA
2026
2028
INTER

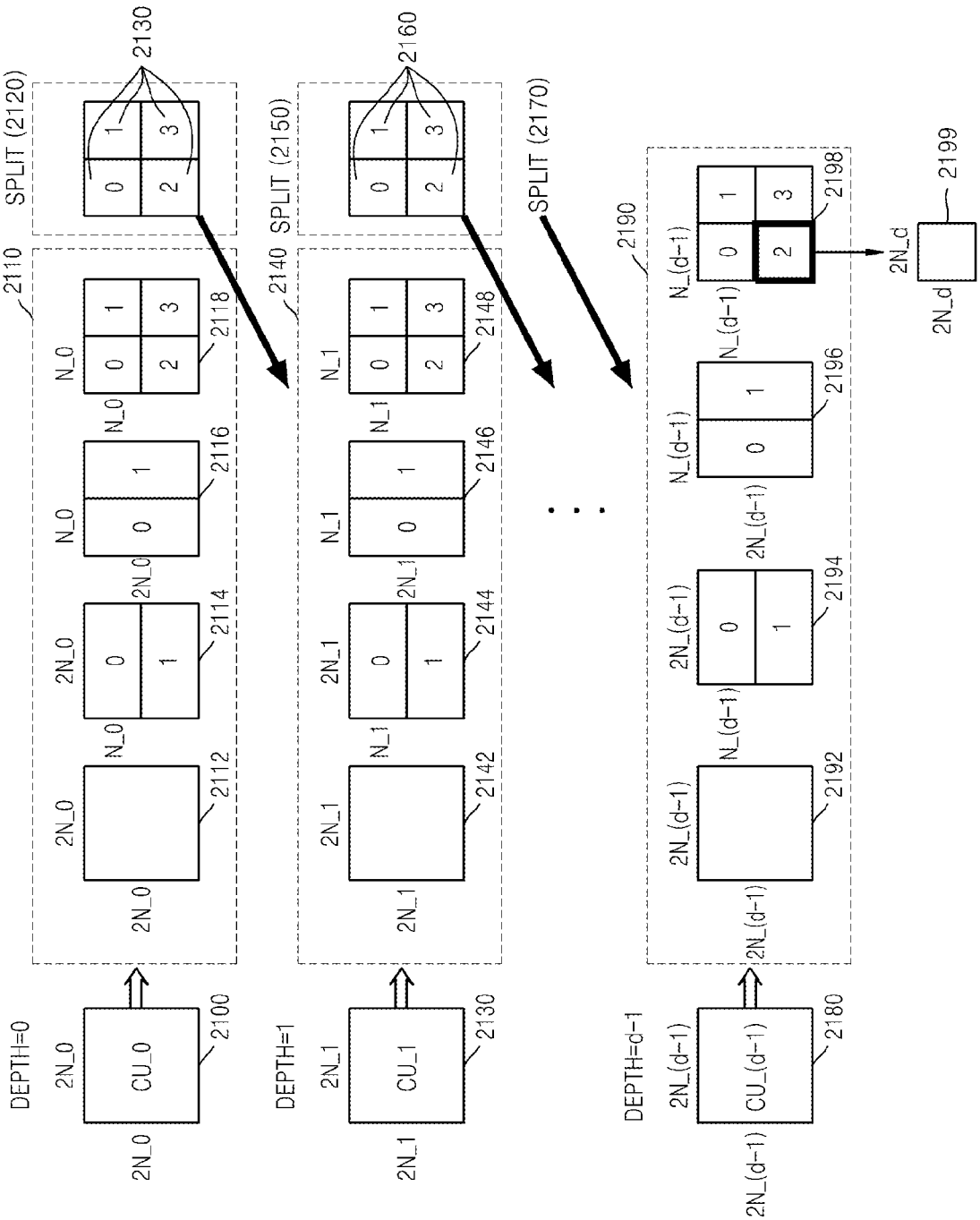
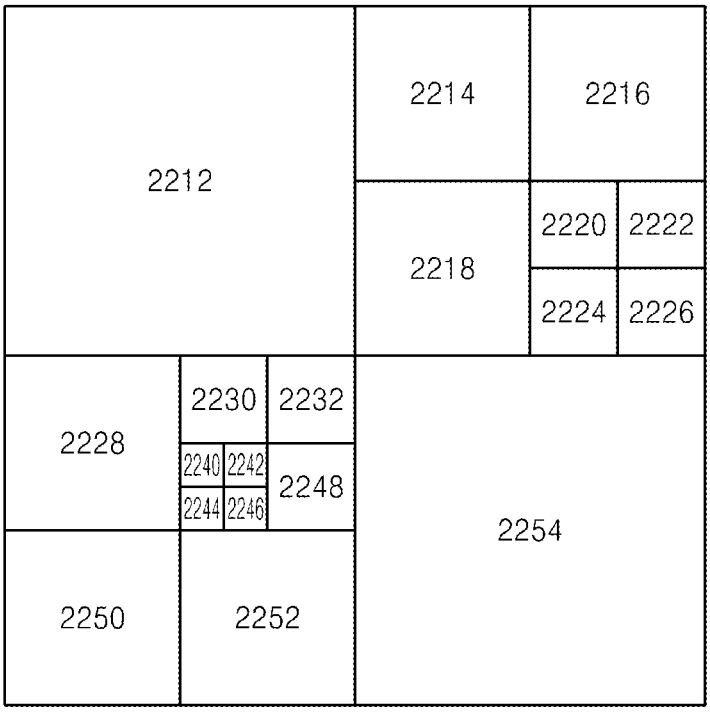

DEPTH=0
DEPTH=1
DEPTH=d-1
CU_0
CU_1
CU_(d-1)
2100
2130
2180
2110
2140
2190
SPLIT (2120)
SPLIT (2150)
SPLIT (2170)
2112
2114
2116
2118
2142
2144
2146
2148
2192
2194
2196
2198
2199
2N_0
2N_1
2N_(d-1)
2N_d
N_0
N_1
N_(d-1)
0
1
2
3

FIG. 21

FIG. 22



CODING UNIT (2210)

FIG. 23

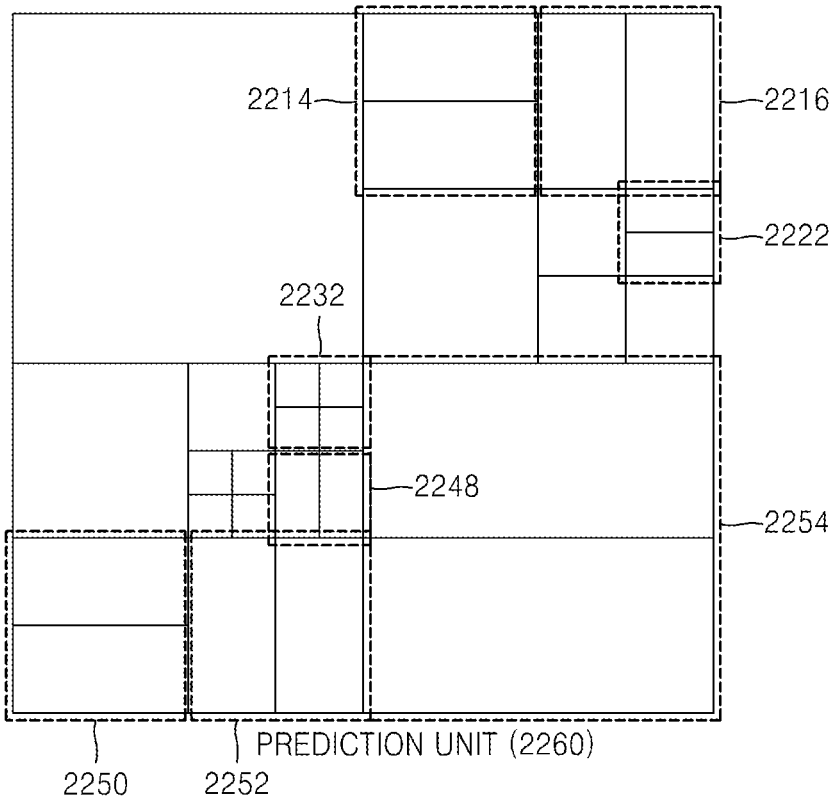

2214
2216
2222
2232
2248
2254
PREDICTION UNIT (2260)
2250
2252

FIG. 24

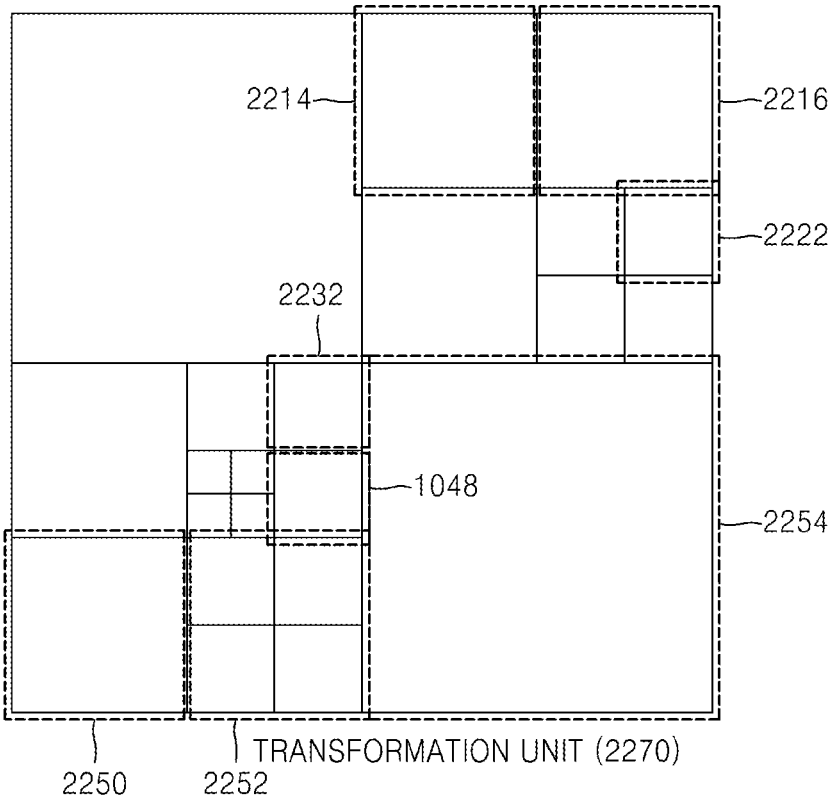

2214
2216
2222
2232
1048
2254
2250
2252
TRANSFORMATION UNIT (2270)

FIG. 25

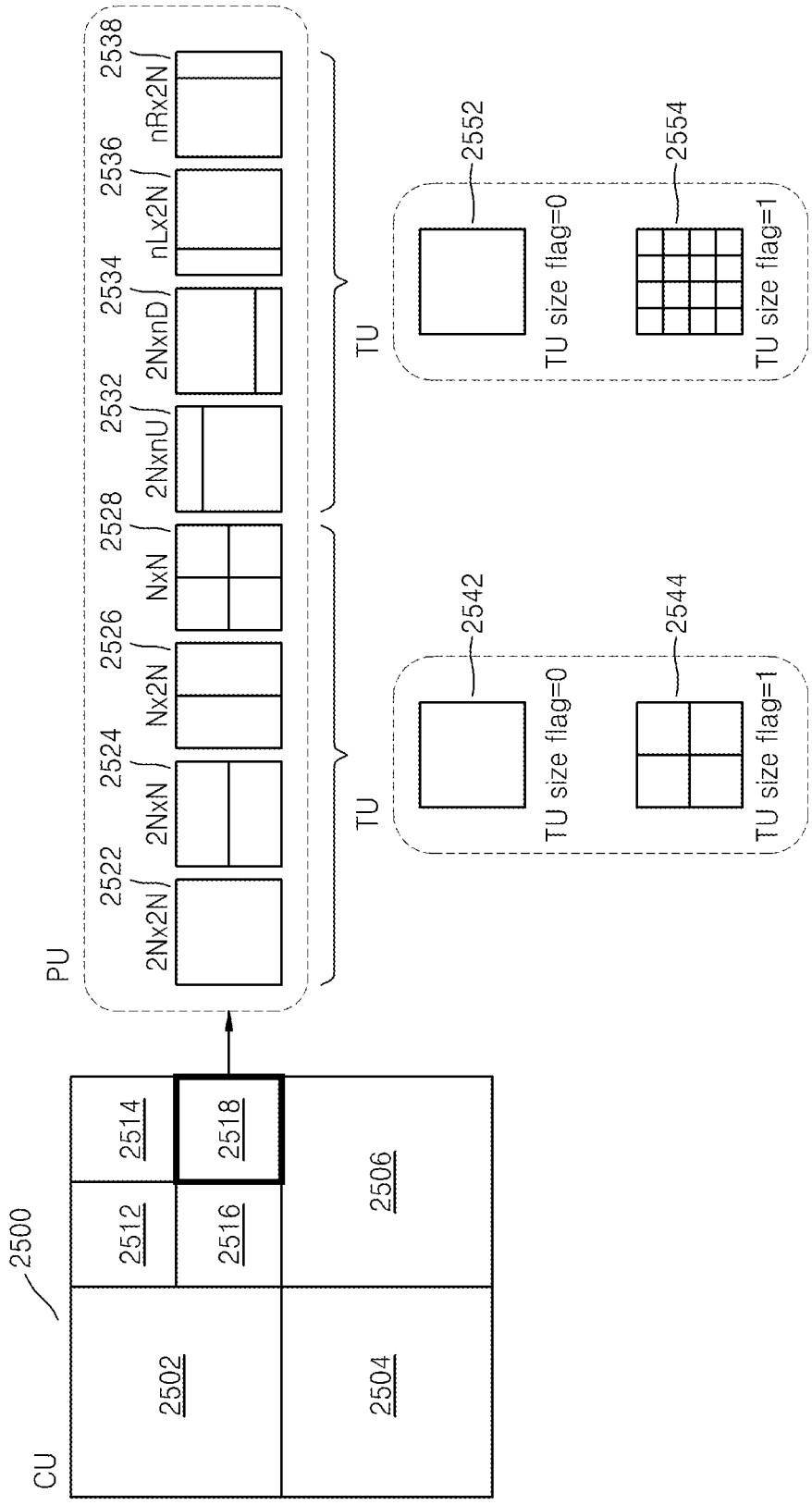

CU
2500
2502
2504
2506
2512
2514
2516
2518
PU
2522
2Nx2N
2524
2NxN
2526
Nx2N
2528
NxN
2532
2NxnU
2534
2NxnD
2536
nLx2N
2538
nRx2N
TU
TU
2542
TU size flag=0
2544
TU size flag=1
2552
TU size flag=0
2554
TU size flag=1

FIG. 26A

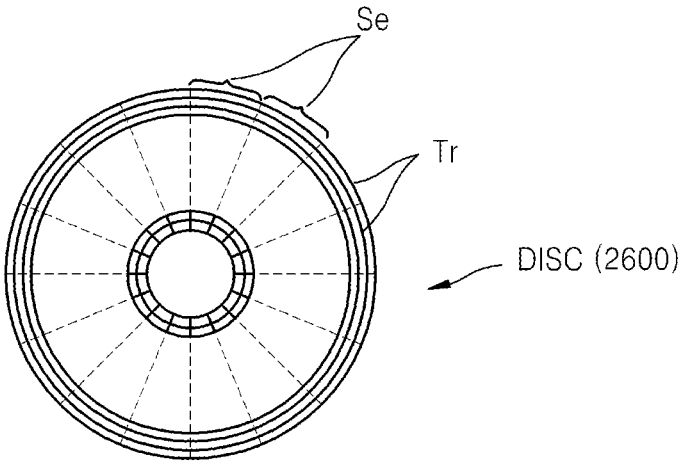


FIG. 26B

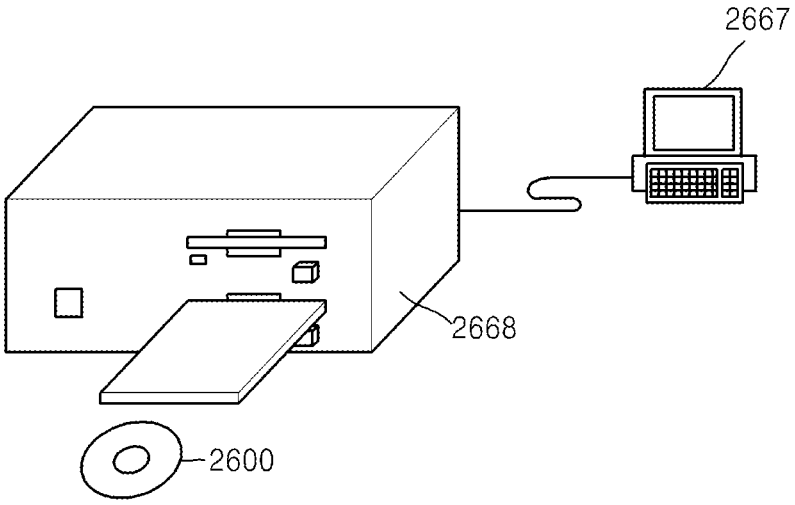


FIG. 27

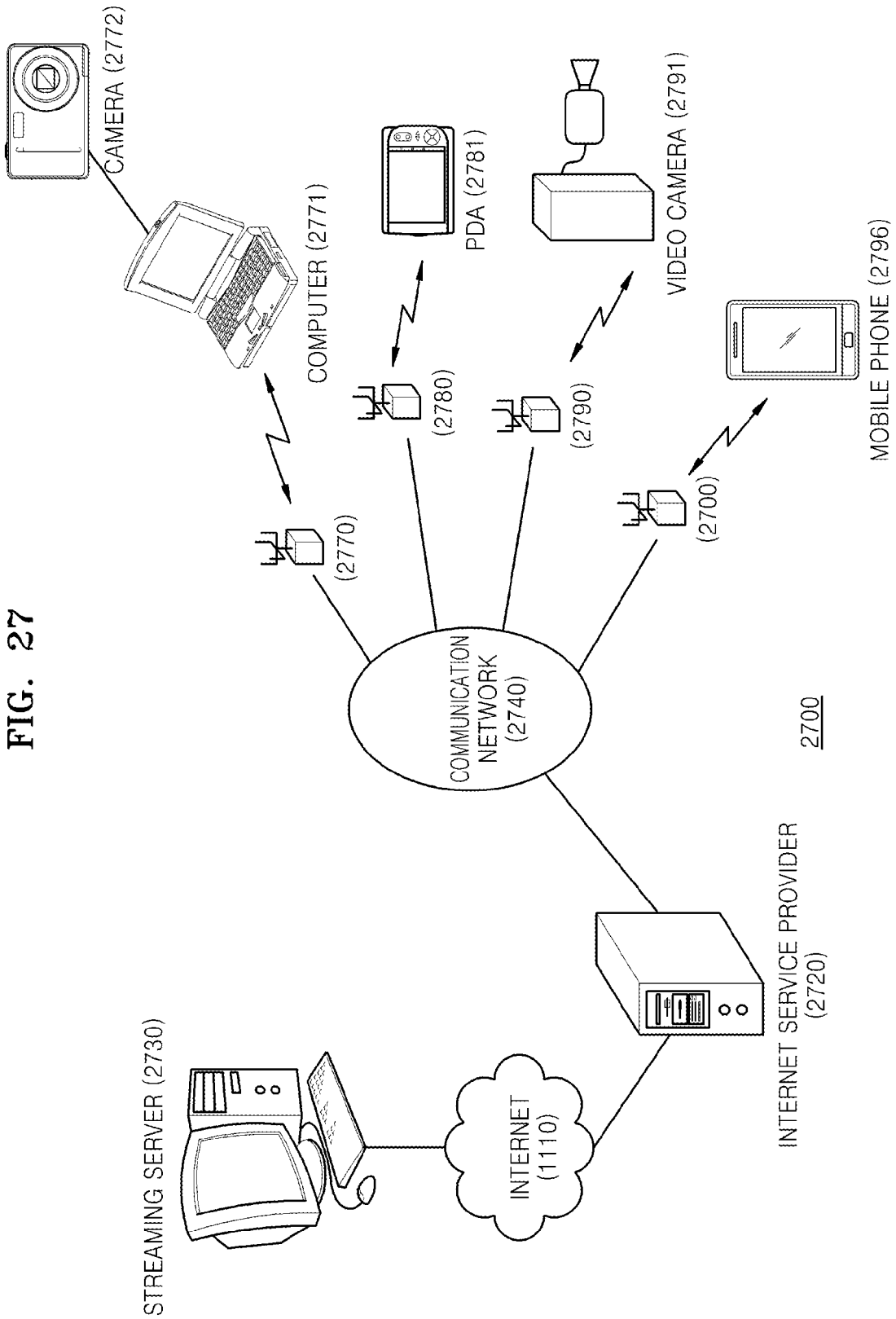

CAMERA (2772)
COMPUTER (2771)
PDA (2781)
VIDEO CAMERA (2791)
MOBILE PHONE (2796)
(2770)
(2780)
(2790)
(2700)
COMMUNICATION NETWORK (2740)
INTERNET SERVICE PROVIDER (2720)
INTERNET (1110)
STREAMING SERVER (2730)
2700

FIG. 28

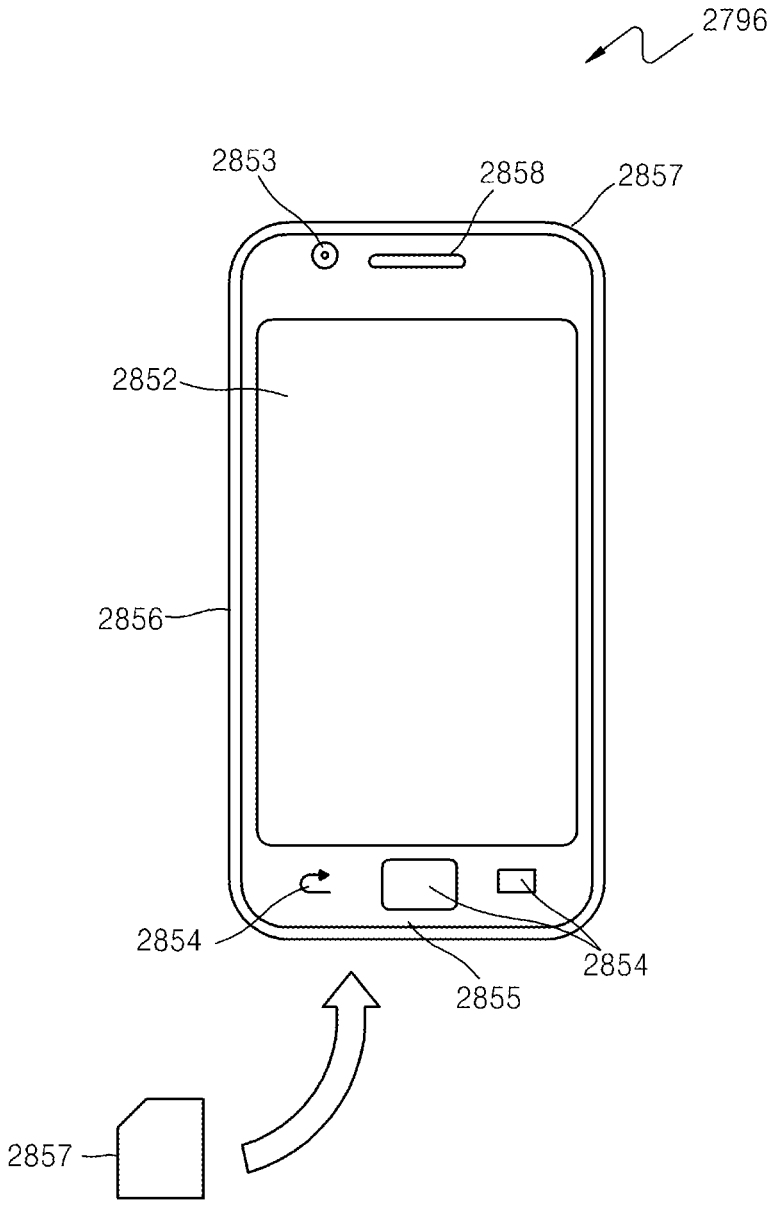


FIG. 29

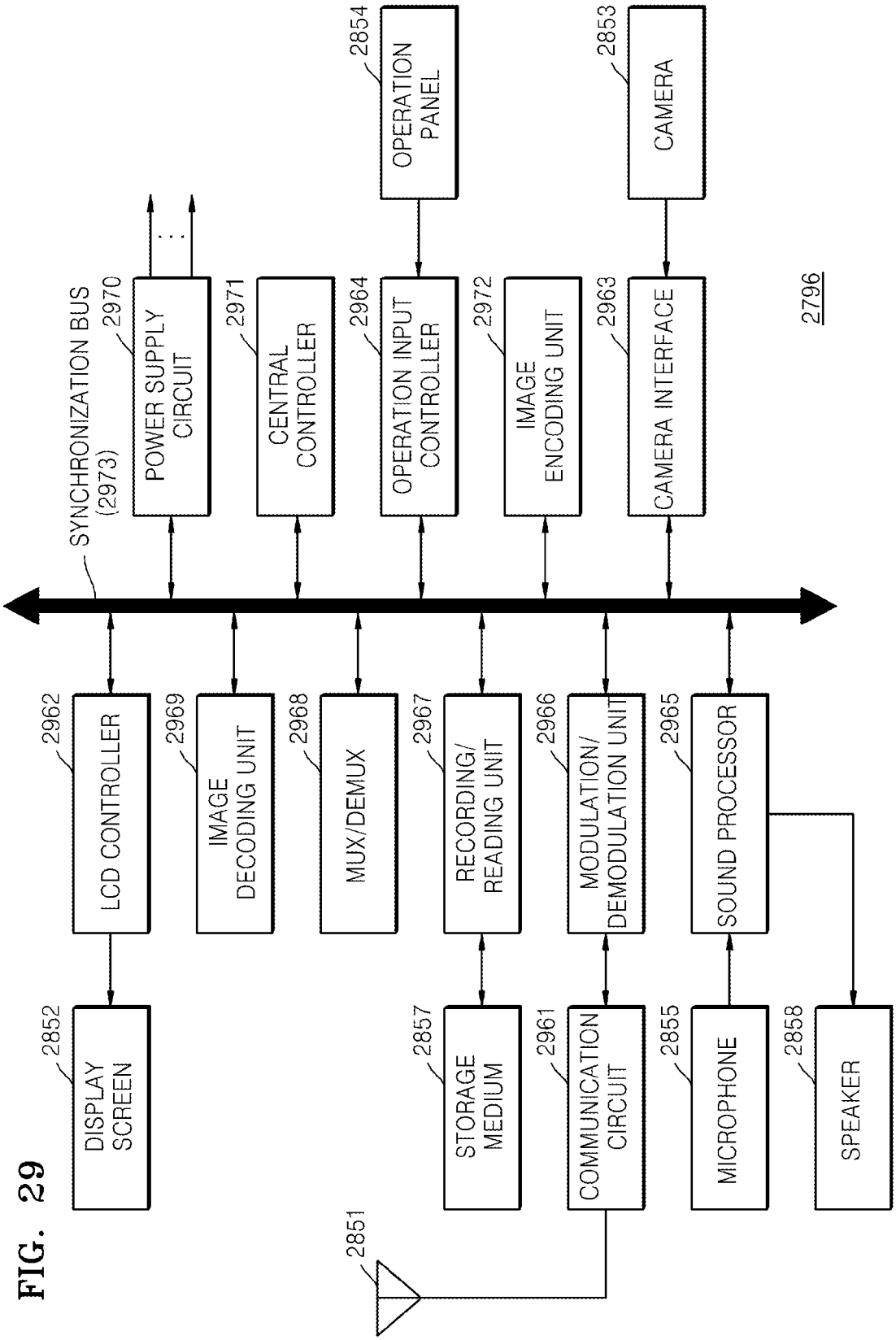

2796
SYNCHRONIZATION BUS (2973)
2970 POWER SUPPLY CIRCUIT
2971 CENTRAL CONTROLLER
2964 OPERATION INPUT CONTROLLER
2972 IMAGE ENCODING UNIT
2963 CAMERA INTERFACE
2854 OPERATION PANEL
2853 CAMERA
2962 LCD CONTROLLER
2969 IMAGE DECODING UNIT
2968 MUX/DEMUX
2967 RECORDING/ READING UNIT
2966 MODULATION/ DEMODULATION UNIT
2965 SOUND PROCESSOR
2852 DISPLAY SCREEN
2857 STORAGE MEDIUM
2961 COMMUNICATION CIRCUIT
2855 MICROPHONE
2858 SPEAKER
2851

FIG. 30

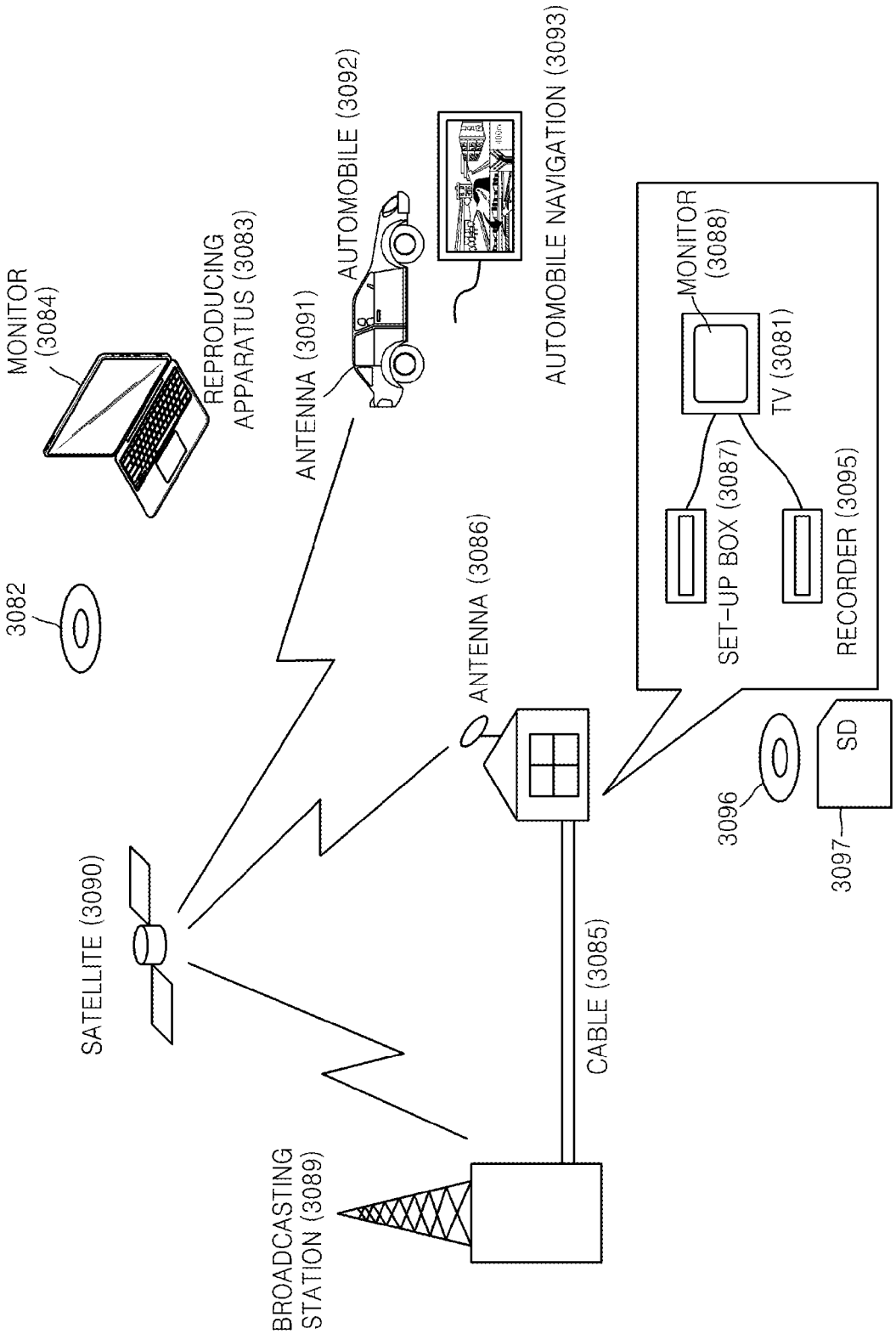
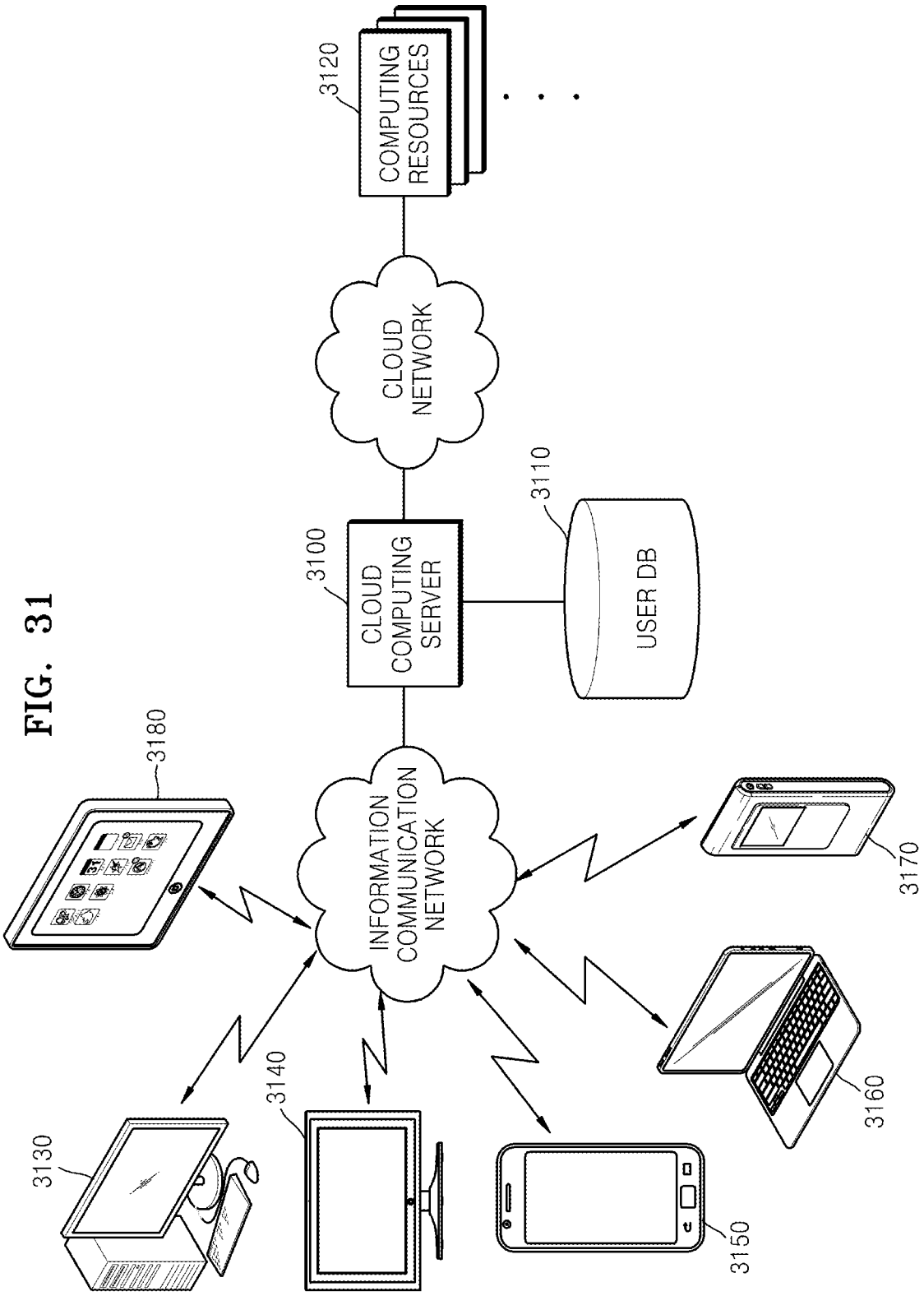

MONITOR (3084)
REPRODUCING APPARATUS (3083)
3082
AUTOMOBILE (3092)
ANTENNA (3091)
AUTOMOBILE NAVIGATION (3093)
MONITOR (3088)
TV (3081)
SET-UP BOX (3087)
RECORDER (3095)
ANTENNA (3086)
SATELLITE (3090)
CABLE (3085)
3096
SD
3097
BROADCASTING STATION (3089)

FIG. 31


3120
COMPUTING RESOURCES
CLOUD NETWORK
3110
3100
CLOUD COMPUTING SERVER
USER DB
3180
INFORMATION COMMUNICATION NETWORK
3170
3130
3140
3160
3150

METHOD AND DEVICE FOR ENCODING A DEPTH MAP OF MULTI VIEWPOINT VIDEO DATA, AND METHOD AND DEVICE FOR DECODING THE ENCODED DEPTH MAP

CROSS-REFERENCE TO RELATED APPLICATION

This application is a National Stage Application under 35 U.S.C. §371 of International Application No. PCT/KR2012/006357, filed on Aug. 9, 2012, and claims the benefit of U.S. Provisional Application No. 61/521,529, filed on Aug. 9, 2011, in the U.S. Patent and Trademark Office, the disclosures of which are incorporated herein by reference in their entireties.

BACKGROUND

1. Field

Exemplary embodiments relate to encoding and decoding multi-view video data including a depth image.

2. Description of Related Art

Recently, as digital image processing and computer graphics technology have been developed, research has been actively conducted on three-dimensional (3D) video technology and multi-view video technology enabling a real world to be reproduced and users to realistically experience the reproduced real world. 3D televisions (TVs) using multi-view video are capable of providing users with realistic feelings by displaying contents obtained by reproducing a real world, and thus have drawn much attention as next-generation broadcasting technology. A 3D video encoding system has a function of supporting multi-view images, via which users may freely change viewpoints or so that the 3D video encoding system can be applied to various types of 3D reproducing apparatuses. However, since an amount of data of multi-view video is high, there is a need to develop an encoding method of efficiently reducing the amount of the data of the multi-view video.

SUMMARY

Exemplary embodiments relate to a method and apparatus for efficiently encoding a depth map image for providing 3D video to multi-view video data, and a method and apparatus for effectively decoding the depth map.

According to an exemplary embodiment, the correlation between peripheral pixels of a color image and peripheral pixels of a depth image is obtained and a block of a current depth image are encoded through intra prediction using a block of a corresponding color image.

According to an aspect of an exemplary embodiment, there is provided a method of encoding a depth map of multi-view video data, the method comprising: obtaining a multi-view color video frame and a depth map frame corresponding to the multi-view color video frame; prediction-encoding and restoring the obtained multi-view color video frame; splitting a block of the restored multi-view color video frame into at least one partition based on a pixel value of the block of the restored multi-view color video frame; obtaining a parameter indicating a correlation between each of block partitions of the multi-view color video frame and each of block partitions of the depth map frame by using peripheral pixel values of the block partitions of the multi-view color video frame and peripheral pixel values of the block partitions of the depth map frame corresponding to the block partitions of the multi-view color video frame with respect to each of the block partitions of the restored multi-view color video frame; and obtaining prediction values of the corresponding block partitions of the depth map frame from the block partitions of the restored multi-view color video frame by using the obtained parameter.

According to an aspect of another exemplary embodiment, there is provided an apparatus for encoding a depth map of multi-view video data, the apparatus comprising: an image obtaining unit for obtaining a multi-view color video frame and a depth map frame corresponding to the multi-view color video frame; a color video frame encoding unit for prediction-encoding the obtained multi-view color video frame; a restoring unit for restoring the encoded color video frame; a splitting unit for splitting a block of the restored multi-view color video frame into at least one partition based on a pixel value of the block of the restored multi-view color video frame; a correlation parameter obtaining unit for obtaining a parameter indicating a correlation between each of block partitions of the multi-view color video frame and each of block partitions of the depth map frame by using peripheral pixel values of the block partitions of the multi-view color video frame and peripheral pixel values of the block partitions of the depth map frame corresponding to the block partitions of the multi-view color video frame with respect to each of the block partitions of the restored multi-view color video frame; and a depth map frame prediction unit for obtaining prediction values of the corresponding block partitions of the depth map frame from the block partitions of the restored multi-view color video frame by using the obtained parameter.

According to an aspect of another exemplary embodiment, there is provided a method of decoding a depth map of multi-view video data, the method comprising: receiving a bitstream obtained by encoding a multi-view color video frame and a depth map frame corresponding to the multi-view color video frame; decoding the multi-view color video frame; splitting a block of the decoded multi-view color video frame into at least one partition based on a pixel value of the block of the decoded multi-view color video frame; obtaining a parameter indicating a correlation between each of block partitions of the multi-view color video frame and each of block partitions of the depth map frame by using peripheral pixel values of the block partitions of the multi-view color video frame and peripheral pixel values of the block partitions of the depth map frame corresponding to the block partitions of the multi-view color video frame with respect to each of the block partitions of the decoded multi-view color video frame; and obtaining prediction values of the corresponding block partitions of the depth map frame from the block partitions of the decoded multi-view color video frame by using the obtained parameter.

According to an aspect of another exemplary embodiment, there is provided an apparatus for decoding a depth map of multi-view video data, the apparatus comprising: a receiving unit for receiving a bitstream obtained by encoding a multi-view color video frame and a depth map frame corresponding to the multi-view color video frame; a color video frame decoding unit for decoding the encoded multi-view color video frame obtained from the bitstream; a splitting unit for splitting a block of the restored multi-view color video frame into at least one partition based on a pixel value of the block of the restored multi-view color video frame; a correlation parameter obtaining unit for obtaining a parameter indicating a correlation between each of block partitions of the multi-view color video frame and each of block partitions of the depth map frame by using peripheral pixel values of the block partitions of the multi-view color video frame and peripheral pixel values of the block partitions of the depth map frame

corresponding to the block partitions of the multi-view color video frame with respect to each of the block partitions of the restored multi-view color video frame; and a depth map decoding unit for obtaining prediction values of the corresponding block partitions of the depth map frame from the block partitions of the restored multi-view color video frame by using the obtained parameter.

Accordingly, multi-view video data having an enormous amount of data can be efficiently compressed by predicting a corresponding depth map frame from a multi-view color video frame. Further, a parameter indicating the correlation is determined from previously encoded peripheral pixel values, and thus it is not necessary to transmit an additional parameter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a multi-view video system according to an exemplary embodiment.

FIG. **2** illustrates multi-view video frames obtained via multi-view cameras of FIG. **1** and depth map frames obtained via a depth camera of FIG. **1**.

FIG. **3** is a block diagram of a multi-view video data encoding apparatus according to an exemplary embodiment.

FIG. **4** is a block diagram of a depth map frame encoding unit of FIG. **3**.

FIGS. **5**A and **5**B are diagrams for explaining a method of splitting a block of a multi-view color video frame into partitions performed by a splitting unit **420** of FIG. **4**.

FIG. **6** is a diagram for explaining a parameter obtaining process performed by a correlation parameter obtaining unit **430** and an intra prediction process performed by a depth map frame prediction unit **440** of FIG. **4**.

FIG. **7** illustrates a multi-view color video frame block used to predict a depth map frame block according to an exemplary embodiment.

FIG. **8** is a flowchart illustrating a method of encoding a depth map of multi-view video data, according to an exemplary embodiment.

FIG. **9** is a block diagram of a multi-view video data decoding apparatus, according to an exemplary embodiment.

FIG. **10** is a block diagram of a depth map frame decoding unit **930** of FIG. **9**, according to an exemplary embodiment.

FIG. **11** is a flowchart illustrating a method of decoding a depth map of multi-view video data, according to an exemplary embodiment.

FIG. **12** illustrates multi-view color video frames encoded based on a method of encoding multi-view video and decoded based on a method of decoding multi-view video, according to an exemplary embodiment.

FIG. **13** is a block diagram of a video encoding apparatus capable of performing video prediction based on coding units having a tree structure, according to an exemplary embodiment.

FIG. **14** is a block diagram of a video decoding apparatus capable of performing video prediction based on coding units having a tree structure, according to an exemplary embodiment.

FIG. **15** illustrates a concept of coding units according to an exemplary embodiment.

FIG. **16** is a block diagram of an image encoder based on coding units, according to an exemplary embodiment.

FIG. **17** is a block diagram of an image decoder based on coding units, according to an exemplary embodiment.

FIG. **18** is a diagram illustrating coding units corresponding to depths, and partitions, according to an exemplary embodiment.

FIG. **19** is a diagram illustrating a correlation between a coding unit and transformation units, according to an exemplary embodiment.

FIG. **20** is a diagram illustrating encoding information corresponding to depths, according to an exemplary embodiment.

FIG. **21** is a diagram illustrating coding units corresponding to depths, according to an exemplary embodiment.

FIGS. **22**, **23**, and **24** are diagrams illustrating a correlation between coding units, prediction units, and transformation units, according to an exemplary embodiment.

FIG. **25** is a diagram illustrating a correlation between a coding unit, a prediction unit, and a transformation unit, according to encoding mode information of Table 1.

FIG. **26**A illustrates a physical structure of a disc that stores a program, according to an exemplary embodiment.

FIG. **26**B illustrates a disc drive that records and reads a program by using a disc.

FIG. **27** illustrates an entire structure of a content supply system that provides content distribution service.

FIGS. **28** and **29** illustrate external and internal structures of a mobile phone to which a video encoding method and a video decoding method are applied, according to an exemplary embodiment.

FIG. **30** illustrates a digital broadcasting system employing a communication system, according to an exemplary embodiment.

FIG. **31** illustrates a network structure of a cloud computing system using a video encoding apparatus and a video decoding apparatus, according to an exemplary embodiment.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Hereinafter, exemplary embodiments will be described in detail with reference to the appended claims.

FIG. **1** is a block diagram of a multi-view video system **100** according to an exemplary embodiment.

The multi-view video system **100** includes a multi-view video data encoding apparatus **110** and a multi-view video data decoding apparatus **120**. The multi-view video data encoding apparatus **110** generates a bitstream by encoding a multi-view video frame obtained via at least two multi-view cameras **130** and a depth map frame corresponding to the multi-view video frame, obtained via a depth camera **140**. The multi-view video data decoding apparatus **120** decodes the bitstream to obtain the decoded multi-view video frame, and provides the decoded multi-view video frame in any of various formats, according to a demand of a viewer.

The at least two multi-view cameras **130** are manufactured by combining a plurality of different view cameras and may provide multi-view video in units of frames. The depth camera **140** provides a depth map frame that represents depth information of a scene with an 8-bit image having 256 gradation levels. The depth camera **140** may measure a distance between the depth camera **140** itself and an object or a background by using infrared rays, and may provide the depth map frame that is proportional or inversely proportional to the distance.

If the multi-view video data encoding apparatus **110** encodes multi-view video data and a depth map frame corresponding thereto and transmits a result of the encoding through bitstream, then the multi-view video data decoding apparatus **120** may not only provide a stereoscopic effect using the existing stereo image or three-dimensional (3D) video but also synthesize 3D video from viewpoints that a

viewer desires, based on the multi-view video frame and the depth map frame included in the bitstream.

An amount of multi-view video data that is to be encoded increases to be proportional to the number of viewpoints, and a depth map image should also be encoded so as to add a stereoscopic effect to multi-view video data. Thus, to realize a multi-view video system as illustrated in FIG. **1**, an enormous amount of multi-view video data should be effectively compressed.

FIG. **2** illustrates multi-view video frames obtained via the at least two multi-view cameras **130** of FIG. **1** and depth map frames obtained via the depth camera **140** of FIG. **1**.

FIG. **2** illustrates a depth map frame **221** captured from a first viewpoint view **0** corresponding to a color video frame **211** captured from the first viewpoint view **0**, a depth map frame **222** captured from a second viewpoint view **1** corresponding to a color video frame **212** captured from the second viewpoint view **1**, and a depth map frame **223** captured from a third viewpoint view **2** corresponding to a color video frame **213** captured from the third viewpoint view **2**. Although FIG. **2** illustrates a multi-view color video frame **210** and a depth map frame **220** corresponding thereto, captured from the three viewpoints view **0**, view **1**, and view **2**, the total number of viewpoints is not limited thereto. In FIG. **2**, the multi-view color video frame **210** may be a luminance component video frame or a chrominance component video frame.

Referring to FIG. **2**, a specific correlation is present between a color video frame and a depth map frame thereof captured from the same viewpoint, since they are obtained by representing an image captured at the same point of time and from the same viewpoint by using a color and depth. That is, when the multi-view color video frame **210** and the corresponding depth map frame **220** are compared, a specific correlation is present therebetween, e.g., the outline of an object may be identified. Thus, the multi-view video data encoding apparatus **110** and the multi-view video data decoding apparatus **120** according to the present embodiment may prediction-encode the corresponding depth map frame **220** based on a result of encoding the multi-view color video frame **210**, in consideration of the correlation between the multi-view color video frame **210** and the corresponding depth map frame **220**, thereby increasing the compression efficiency of multi-view video data. In particular, the multi-view video data encoding apparatus **110** and the multi-view video data decoding apparatus **120** according to the present embodiment split a block of the multi-view color video frame **210** into partitions based on pixel values, split a block of the corresponding depth map frame **220** into partitions in the same manner as the block of the multi-view color video frame **210**, obtain a parameter indicating correlations between the block partitions of the multi-view color video frame **210** and the block partitions of the corresponding depth map frame **220** by using peripheral pixel values of the block partitions of the multi-view color video frame **210** and peripheral pixel values of the block partitions of the corresponding depth map frame **220**, and predict the block partitions of the corresponding depth map frame **220** from the block partitions of the multi-view color video frame **210** by using the correlations determined using the obtained parameter.

FIG. **3** is a block diagram of a multi-view video data encoding apparatus **300** according to an exemplary embodiment.

Referring to FIG. **3**, the multi-view video data encoding apparatus **300** includes an image obtaining unit **310** (e.g., an image obtainer), a color video frame encoding unit **320** (e.g., a color video frame encoder), and a depth map encoding unit **330** (e.g., a depth map encoder).

The image obtaining unit **310** obtains a multi-view color video frame by using multi-view video obtaining units such as the at least two multi-view cameras **130** of FIG. **1**, and obtains a depth map frame corresponding to the multi-view color video frame by using a depth map frame obtaining unit such as the depth camera **140**.

The color video frame encoding unit **320** prediction-encodes the obtained multi-view color video frame. In particular, as will be described below with reference to FIGS. **13** to **25**, the color video frame encoding unit **320** according to the present embodiment may encode the multi-view color video frame based on coding units having a hierarchical structure, instead of general macro blocks. The color video frame encoding unit **320** may determine coding units having a tree structure, including coding units corresponding to a coded depth, from among hierarchical coding units corresponding to depths each denoting the number of times at least one maximum coding unit is spatially split, for each of the at least one maximum coding unit that is split from the multi-view color video frame. The color video frame encoding unit **320** may determine partitions for prediction-encoding each of the coding units corresponding to the coded depth, and may determine transformation units having a tree structure by performing transformation based on transformation units having a hierarchical structure.

The depth map frame encoding unit **330** intra-prediction-encodes the corresponding depth map frame by using the multi-view color video frame restored after being prediction-encoded. As descried above, in particular, the depth map frame encoding unit **330** according to the present embodiment considers a correlation between the depth map frame and the corresponding multi-view color video frame when the depth map frame is encoded, splits a block of the multi-view color video frame restored after being prediction-encoded into partitions to determine the correlation, determines a parameter indicating the correlation between a color image and a depth map image for each partition in consideration of correlations between adjacent peripheral pixels, and predicts block partitions of the corresponding depth map frame from the block partitions of the multi-view color video frame restored after being prediction-encoded by using the determined parameter.

FIG. **4** is a block diagram of the depth map frame encoding unit **330** of FIG. **3**.

Referring to FIG. **4**, a depth map frame encoding unit **400** includes a scaling unit **410** (e.g., a scaler), a splitting unit **420** (e.g., a splitter), a correlation parameter obtaining unit **430** (e.g., a correlation parameter obtainer), a depth map frame prediction unit **440** (e.g., a depth map frame predictor), and a subtraction unit **450** (e.g., a subtractor).

The scaling unit **410** samples a block of a multi-view color video frame in such a way that a size of the block of the multi-view color video frame is identical to a size of a block of a depth map frame in a case where the size of the block of the depth map frame is different from the size of the block of the multi-view color video frame. For example, if the size of the block of the multi-view color video frame is 2N×2N (N is an integral number), and the size of the block of the corresponding depth map frame is N×N, the scaling unit **410** may generate the block of the multi-view color video frame by down-sampling the block of the multi-view color video frame at a rate of 1:2.

The splitting unit **420** splits the block of the multi-view color video frame restored after being encoded into at least one partition based on pixel values of the restored block of the multi-view color video frame. The splitting unit **420** further

splits the block of the depth map frame into partitions in the same manner as the block partitions of the multi-view color video frame.

FIGS. **5**A and **5**B are diagrams for explaining a method of splitting a block of a multi-view color video frame into partitions performed by the splitting unit **420** of FIG. **4**.

The splitting unit **420** may split the block of the multi-view color video frame into partitions based on a distribution of pixel values of the block of the multi-view color video frame so that pixels having pixel values similar to a predetermined pixel value may be included in the same partition. The splitting unit **420** may analyze the distribution of pixel values of the block of the multi-view color video frame, determine the predetermined pixel value that is a reference of the partition split, and classify pixels within a range of ±x (x is an integral number) from the predetermined pixel value into a single partition. For example, referring to FIG. **5**A, the splitting unit **420** may classify pixels having pixel values within a range of ±10 with respect to a pixel value of 125 into a first partition **510** and classify pixels having pixel values within a range of ±10 with respect to a pixel value of 70 into a second partition **520**. The method of splitting the block into partitions based on the distribution of pixel values is not limited thereto. The splitting unit **420** may split the block into a plurality of partitions based on the distribution of pixel values by applying various data clustering methods.

Referring to FIG. **5**B, the splitting unit **420** may detect an edge present in the block of the multi-view color video frame by applying various edge detection methods such as a sobel algorithm, and classify the block of the multi-view color video frame into a first partition **530** and a second partition **540** based on the detected edge.

If the block of the multi-view color video frame is split into a plurality of partitions by using the splitting unit **420**, the correlation parameter obtaining unit **430** obtains a parameter indicating a correlation between each of the block partitions of the multi-view color video frame and each of the block partitions of the depth map frame by using peripheral pixel values of the block partitions of the multi-view color video frame and peripheral pixel values of the block partitions of the depth map frame corresponding to the block partitions of the multi-view color video frame with respect to each of the block partitions of the multi-view color video frame.

The depth map frame prediction unit **440** obtains prediction values of the block partitions of the corresponding depth map frame from the block partitions of the restored multi-view color video frame by using the obtained parameter.

FIG. **6** is a conceptual diagram for explaining a parameter obtaining process performed by the correlation parameter obtaining unit **430** and an intra prediction process performed by the depth map frame prediction unit **440** of FIG. **4**.

Referring to FIG. **6**, it is assumed that a block **610** of a multi-view color video frame is split into two partitions P**1** and P**2** by the splitting unit **420**. The splitting unit **420** splits a block **640** of a depth map frame into two partitions P**1'** and P**2'** so that the two partitions P**1'** and P**2'** have the same sizes and shape as the two partitions P**1** and P**2** of the block **610** of the multi-view color video frame.

The correlation parameter obtaining unit **430** obtains a parameter indicating a correlation with respect to each of the two partitions P**1** and P**2** of the block **610** of the multi-view color video frame. More specifically, the correlation parameter obtaining unit **430** obtains a first parameter indicating the correlation between the partition P**1** of the block **610** of the multi-view color video frame and the partition P**1'** of the block **640** of the depth map frame by using peripheral pixel values **620** of the partition P**1** of the block **610** of the multi-view color video frame and peripheral pixel values **650** of the partition P**1'** of the block **640** of the corresponding depth map frame. Further, the correlation parameter obtaining unit **430** obtains a second parameter indicating the correlation between the partition P**2** of the block **610** of the multi-view color video frame and the partition P**2'** of the block **640** of the depth map frame by using peripheral pixel values **630** of the partition P**2** of the block **610** of the multi-view color video frame and peripheral pixel values **660** of the partition P**2'** of the block **640** of the corresponding depth map frame.

If a pixel of the multi-view color video frame is R, and a prediction value of a corresponding pixel of the depth map frame having the same location as that of the pixel R is D, the prediction value D may be obtained through a function f( ) indicating a correlation between the multi-view color video frame and the depth map frame such as an equation: D=f(R). If it is assumed that the function indicating the correlation is a linear function such as an equation: f(x)=aX+b (a and b are real numbers), a linear relation is defined by using a weight a and an offset b.

The correlation parameter obtaining unit **430** according to an exemplary embodiment obtains the weight a and the offset b for each partition by using peripheral pixel values **620** and **630** of block partitions of the multi-view color video frame restored after being encoded and peripheral pixel values **650** and **660** of the depth map frame so that the weight a and the offset b indicating the linear relation may be obtained in a receiving side without being not separately signaled.

The correlation parameter obtaining unit **430** independently processes the block partitions of the multi-view color video frame and the block partitions of the depth map frame and obtains the parameter indicating the correlation by using the peripheral pixels **620**, **630**, **650**, and **660** of the block partitions. Referring to FIG. **6**, the correlation parameter obtaining unit **430** predicts the peripheral pixel values **650** of the block partition P'**1** of the corresponding depth map frame by using the peripheral pixel values **620** of the block partition P**1** of the multi-view color video frame. For example, a prediction value D'(x,y) of a peripheral pixel value D(x,y) **651** of the block partition P**1** ' of the corresponding depth map frame at the same location using a peripheral pixel value R(x,y) **621** of the block partition P**1** of the multi-view color video frame is obtained through an equation: D'(x,y)=a*R(x,y)+b. The correlation parameter obtaining unit **430** predicts the peripheral pixel values **650** of the block partition P**1** ' of the corresponding depth map frame by using each of the peripheral pixel values **620** of the block partition P**1** of the multi-view color video frame, and determines the weight a and the offset b so that a difference (D(x,y)−D'(x,y)) between the predicted peripheral pixel values **650** of the block partition P**1'** of the corresponding depth map frame and the original peripheral pixel values **660** of the block partition P**1'** of the corresponding depth map frame is minimized. In this regard, the correlation parameter obtaining unit **430** may predict the peripheral pixel values **650** of the block partition P**1'** of the corresponding depth map frame with respect to each of the peripheral pixel values **620** of the block partition P**1** of the multi-view color video frame, and determine the weight a and the offset b so that a sum of square of the difference (D(x,y)−D'(x,y)) is minimized (Least Square Solution).

Similarly, the correlation parameter obtaining unit **430** predicts the peripheral pixel values **660** of the block partition P**2'** of the corresponding depth map frame by using the peripheral pixel values **630** of the block partition P**2** of the multi-view color video frame. The correlation parameter obtaining unit **430** predicts the peripheral pixel values **660** of the block partition P**2'** of the corresponding depth map frame by using

each of the peripheral pixel values **630** of the block partition P**2** of the multi-view color video frame, and determines the weight a and the offset b so that a difference between the predicted peripheral pixel values **660** of the block partition P**2'** of the corresponding depth map frame and the original peripheral pixel values **660** of the block partition P**2'** of the corresponding depth map frame is minimized.

As described above, the correlation parameter obtaining unit **430** independently predicts a parameter indicating a correlation by using peripheral pixels for each partition. If peripheral pixel values of the block partitions of the multi-view color video frame is Rec_Y' and prediction values of the corresponding peripheral pixel values of the block partitions of the depth map frame is Pred_D, the correlation parameter obtaining unit **430** predicts peripheral pixels of the depth map frame through an equation: Pred_D=a*Rec_Y'+b, and determines the parameters a and b so that a difference between the original peripheral pixels and the predicted peripheral pixels is minimized. Although the process of determining the parameter is described assuming a primary linear relation above, the inventive concept is not limited thereto and may be applied to a process of obtaining an optimal parameter using peripheral pixels when a parameter for defining an n-th linear relation equation or another non-linear relation equation is obtained.

If the correlation parameter obtaining unit **430** obtains the parameter indicating the correlation for each partition, the depth map frame prediction unit **440** obtains prediction values of the block partitions of the corresponding depth map frame from the block partitions of the restored multi-view color video frame using the obtained parameter. Referring back to FIG. **6**, it is assumed that a weight and an offset determined with respect to the block partition P**1** of the multi-view color video frame restored after being encoded are a**1** and b**1**, respectively. The depth map frame prediction unit **440** generates a prediction value of a corresponding pixel D**1'** **641** of the block partition P**1'** of the depth map frame from a pixel R**1** **611** of the block partition P**1** of the multi-view color video frame using a linear relation equation such as an equation: D**1'**=a**1** *R**1**+b**1**. Similarly, if it is assumed that a weight and an offset determined with respect to the block partition P**2** of the multi-view color video frame restored after being encoded are a**2** and b**2**, respectively, the depth map frame prediction unit **440** generates a prediction value of a corresponding pixel D**2'** **642** of the block partition P**2'** of the depth map frame from a pixel R**2** **612** of the block partition P**2** of the multi-view color video frame by using a linear relation equation such as an equation: D**2'**=a**2** *R**2**+b**2**. As described above, the depth map frame prediction unit **440** predicts the block partitions of the depth map frame from the block partitions of the multi-view color video frame by using the parameter indicating the correlation determined in a partition unit.

Referring back to FIG. **4**, the subtraction unit **450** generates a depth map residue by calculating a difference value between original pixel values of a depth map frame and predicted pixel values of the depth map frame. The depth map residue is encoded through transformation, quantization, and entropy encoding processes like a general residue.

FIG. **7** illustrates a multi-view color video frame block used to predict a depth map frame block **740** according to an exemplary embodiment.

Referring to FIG. **7**, the depth map frame block **740** may be predicted by using a color video frame block **710** that is co-viewed (same view) and co-located (same location) with a current depth map frame block to be encoded **740**. If a size of the color video frame block **710** that is co-viewed and co-located with the current depth map frame block to be encoded **740** is different from a size of the current depth map frame block to be encoded **740**, a scaled block may be used to have the same size as described above. Further, the current depth map frame block to be encoded **740** may be predicted by using peripheral blocks **711** and **712** of the color video frame block **710** that is co-viewed and co-located with the current depth map frame block to be encoded **740**. If sizes of the peripheral blocks **711** and **712** are different from the size of the current depth map frame block to be encoded **740**, a scaled peripheral block may be used to have the same size with the current depth map frame block to be encoded **740**. A different view color video frame block **730** and peripheral blocks **731** and **732** thereof determined by moving the color video frame block **710** that is co-viewed and co-located with the current depth map frame block to be encoded **740** based on a disparity vector indicating a view difference between multi-view video may also be used to predict the current depth map frame block to be encoded **740**. If sizes of the different view color video frame block **730** and peripheral blocks **731** and **732** are different from the size of the current depth map frame block to be encoded **740**, the different view color video frame block **730** and peripheral blocks **731** and **732** are scaled to have the same size as that of the current depth map frame block to be encoded **740**, and the scaled different view color video frame block **730** and peripheral blocks **731** and **732** may be used to predict the current depth map frame block to be encoded **740**.

FIG. **8** is a flowchart illustrating a method of encoding a depth map of multi-view video data, according to an exemplary embodiment.

Referring to FIG. **8**, in operation **810**, the image obtaining unit **310** obtains a multi-view color video frame and a depth map frame corresponding to the multi-view color video frame.

In operation **820**, the color video frame encoding unit **320** prediction-encodes and restores the obtained multi-view color video frame.

In operation **830**, the depth map frame encoding unit **330** splits a block of the restored multi-view color video frame into at least one partition based on a pixel value of the restored multi-view color video frame.

In operation **840**, the depth map frame encoding unit **330** obtains a parameter indicating a correlation between each of the block partitions of the multi-view color video frame and block partitions of the depth map frame by using peripheral pixel values of the block partitions of the multi-view color video frame and peripheral pixel values of the block partitions of the depth map frame corresponding to the block partitions of the multi-view color video frame with respect to each of the block partitions of the restored multi-view color video frame.

In operation **850**, the depth map frame encoding unit **330** obtains prediction values of the corresponding block partitions of the depth map frame from the block partitions of the restored multi-view color video frame by using the obtained parameter. The depth map frame encoding unit **330** encodes the depth map frame by transforming, quantizing, and entropy-encoding a residue that is a difference value between the prediction values and the original block partitions of the depth map frame.

FIG. **9** is a block diagram of a multi-view video data decoding apparatus **900** according to an exemplary embodiment.

Referring to FIG. **9**, the multi-view video data decoding apparatus **900** includes a receiving unit **910** (e.g., a receiver), a color video frame decoding unit **920** (e.g., a color video frame decoder), and a depth map frame decoding unit **930** (e.g., a depth map frame decoder).

The receiving unit **910** receives a bitstream containing a result of encoding a multi-view color video frame and a depth map frame corresponding to the multi-view color video frame.

The color video frame decoding unit **920** decodes the encoded multi-view color video frame obtained from the bitstream. As will be described with reference to FIGS. **13** to **25** below, particularly, the color video frame decoding unit **920** according to an exemplary embodiment may decode the multi-view color video frame based on hierarchical coding units. The color video frame decoding unit **920** obtains information about the size of each of at least one maximum coding unit split from the multi-view color video frame, a depth denoting the number of times each of the at least one maximum coding unit is spatially split, partitions used to prediction-encode hierarchical coding units according to depths, and transformation units having a hierarchical structure from the bitstream. Also, based on the obtained information, the color video frame decoding unit **920** determines coding units having a tree structure including coding units corresponding to a coded depth from among hierarchical coding units corresponding to depths each denoting the number of times one of the at least one maximum coding unit is spatially split, for each of the at least one maximum coding unit split from the multi-view color video frame, determines partitions for prediction-decoding each of the coding units corresponding to the coded depth; and determines transformation units having a tree structure.

The depth map frame decoding unit **930** prediction-decodes the corresponding depth map frame, based on a result of decoding the multi-view color video frame. Specifically, the depth map frame decoding unit **930** decodes the corresponding depth map frame using the restored multi-view color video frame. In particular, the depth map frame decoding unit **930** according to an exemplary embodiment considers a correlation between the depth map frame and the corresponding multi-view color video frame when the depth map frame is decoded, splits a block of the decoded multi-view color video frame into partitions based on a pixel value so as to determine the correlation, determines a parameter indicating a color image and the depth map image for each partition in consideration of correlations between adjacent peripheral pixels, and predicts block partitions of the corresponding depth map frame from block partitions of the decoded multi-view color video frame using the determined parameter.

FIG. **10** is a block diagram of a detailed construction of the depth map frame decoding unit **930** of FIG. **9**, according to an exemplary embodiment.

Referring to FIG. **10**, a depth map frame decoding unit **1000** includes a scaling unit **1010** (e.g., a scaler), a splitting unit **1020** (e.g., a splitter), a correlation parameter obtaining unit **1030** (e.g., a correlation parameter obtainer), a depth map frame prediction unit **1040** (e.g., a depth map frame predictor), and an adding unit **1050** (e.g., an adder).

The scaling unit **1010** samples a block of a multi-view color video frame in such a way that a size of the block of the multi-view color video frame is identical to a size of a block of a depth map frame in a case where the size of the block of the depth map frame is different from the size of the block of the multi-view color video frame. The splitting unit **1020** splits the block of the multi-view color video frame into at least one partition based on a pixel value of the decoded multi-view color video frame. The splitting unit **1020** further splits the block of the depth map frame into partitions in the same manner as the block partitions of the multi-view color video frame.

If the block of the multi-view color video frame is split into the plurality of partitions by the splitting unit **1020**, the correlation parameter obtaining unit **1030** obtains a parameter indicating a correlation between each of the block partitions of the multi-view color video frame and each of the block partitions of the depth map frame by using peripheral pixel values of the block partitions of the multi-view color video frame and peripheral pixel values of the block partitions of the previously decoded depth map frame corresponding to the block partitions of the multi-view color video frame with respect to each of the block partitions of the multi-view color video frame.

The depth map frame prediction unit **1040** obtains prediction values of the corresponding depth map frame block partitions from the block partitions of the decoded multi-view color video frame by using the obtained parameter. Similarly to the prediction value obtaining process performed by the depth map frame prediction unit **440** of FIG. **4** described above, the depth map frame prediction unit **1040** predicts block partitions of the corresponding depth map frame from the block partitions of the multi-view color video frame by using a weight and an offset determined for each of the block partitions of the decoded multi-view color video frame.

The adding unit **1050** obtains a depth map residue that is a difference value between a pixel value of an original depth map frame and a pixel value of a predicted depth map frame from a bitstream, adds the prediction values obtained by the depth map frame prediction unit **1040** to the depth map residue, and restores the block partitions of the depth map frame. The depth map residue may be restored through entropy decoding, inverse quantization, and inverse transformation like a general residue.

FIG. **11** is a flowchart illustrating a method of decoding a depth map of multi-view video data, according to an exemplary embodiment.

Referring to FIG. **11**, in operation **1110**, the receiving unit **910** receives and parses a bitstream obtained by encoding a multi-view color video frame and a depth map frame corresponding to the multi-view color video frame.

In operation **1120**, the color video frame decoding unit **920** decodes the multi-view color video frame. As will be described below, the color video frame decoding unit **920** may decode the multi-view color video frame based on coding units of a hierarchical structure.

In operation **1130**, the depth map frame decoding unit **930** splits a block of the decoded multi-view color video frame into at least one partition based on a pixel value of the block of the decoded multi-view color video frame.

In operation **1140**, the depth map frame decoding unit **930** obtains a parameter indicating a correlation between each of block partitions of the multi-view color video frame and each of block partitions of the depth map frame by using peripheral pixel values of the block partitions of the multi-view color video frame and peripheral pixel values of the block partitions of the depth map frame corresponding to the block partitions of the multi-view color video frame with respect to each of the block partitions of the decoded multi-view color video frame.

In operation **1150**, the depth map frame decoding unit **930** obtains prediction values of the corresponding block partitions of the depth map frame from the block partitions of the decoded multi-view color video frame by using the obtained parameter. The depth map frame decoding unit **930** restores the block partitions of the depth map frame by adding the obtained prediction values to a depth map residue.

FIG. **12** illustrates multi-view color video frames encoded based on a method of encoding multi-view video and decoded based on a method of decoding multi-view video, according to an exemplary embodiment.

The color video frame encoding unit **320** of FIG. **3** compression-encodes multi-view video, based on a temporal correlation and a spatial correlation between inter-views of cameras.

In FIG. **12**, the x-axis denotes time, and the y-axis denotes viewpoints. In the x-axis, 'T**0**' to 'T**8**' denote sampling times of an image. In the y-axis, 'S**0**' to 'S**8**' denote different viewpoints. In FIG. **12**, each row denotes an image picture group captured from the same viewpoint, and each column denotes multi-view videos captured at the same point of time.

The color video frame encoding unit **320** of FIG. **3** periodically generates intra pictures for an image captured from a basic viewpoint, and prediction-encodes other pictures by performing temporal prediction or inter-view prediction based on the intra pictures.

Temporal prediction is performed using a temporal relationship between images captured from the same viewpoint, i.e., images in the same row in FIG. **12**. For temporal prediction, a predicting scheme using hierarchical B pictures may be used. Inter-view prediction is performed using a spatial relationship between images at the same point of time, i.e., images in the same column in FIG. **12**.

In the predicting scheme for predicting a multi-view video picture by using hierarchical B pictures, when prediction is performed using a temporal relationship between images from the same viewpoint, i.e., images in the same row, a image picture group from the same viewpoint is prediction-encoded as bi-directional picture (hereinafter referred to as 'B picture'), based on anchor pictures. Here, the anchor pictures mean pictures arranged in a column **1210** at a first point of time T**0** and a column **1220** at a last point of time T**8**, which each include an intra picture, from among the columns in FIG. **12**. The anchor pictures arranged in the columns **1210** and **1220** are prediction-encoded only through inter-view prediction, except for the intra pictures (hereinafter referred to as 'I pictures'). Pictures arranged in the other columns except for the columns **1210** and **1220** including the I pictures are referred to as 'non-anchor pictures'.

For example, a case where image pictures captured from a first viewpoint S**0** for a predetermined time are encoded using the hierarchical B pictures will now be described. Among the image pictures captured from the first viewpoint S**0**, a picture **1211** captured at the first point of time TO and a picture **1221** captured at the last point of time T**8** are encoded as the I pictures. Then, a picture **1231** captured at a point of time T**4** is bi-directionally prediction-encoded as a B picture, based on the I pictures **1211** and **1221** which are anchor pictures. A picture **1232** captured at a point of time T**2** is bi-directionally prediction-encoded as a B picture, based on the I picture **1211** and the B picture **1231**. Similarly, a picture **1233** captured at a point of time T**1** is bi-directionally prediction-encoded based on the I picture **1211** and the B picture **1232**, and a picture **1234** captured at a point of time T**3** is bi-directionally prediction-encoded based on the B picture **132** and the B picture **1231**. As described above, since image sequences captured from the same viewpoint are hierarchically and bi-directionally prediction-encoded using anchor pictures, this prediction-encoding method is referred to as hierarchical B pictures. In 'Bn' of FIG. **12**, n denotes a B picture that is n^{th} bi-directionally predicted (n=1, 2, 3, and 4). For example, 'B**1** ' denotes a picture that is first bi-directionally predicted using anchor pictures which are I pictures or P pictures, 'B**2**' denotes a picture that is bi-directionally predicted after the B**1** picture, 'B**3**' denotes a picture that is bi-directionally predicted after the B**2** picture, and 'B**4**' denotes a picture that is bi-directionally predicted after the B**3** picture.

To encode a multi-view video frame, first, image picture groups captured from the first viewpoint S**0** which is a basic viewpoint are encoded using the hierarchical B pictures described above. To encode image sequences captured from the other viewpoints, first, image pictures captured from odd-numbered viewpoints S**2**, S**4**, and S**6** and a last viewpoint S**7** in the columns **1210** and **1220** are prediction-encoded using P pictures through inter-view prediction using the I pictures **1211** and **1221** from the first viewpoint S**0**. Image pictures captured from even-numbered viewpoints S**1**, S**3**, and S**5** in the columns **1210** and **1220** are bi-directionally predicted as B pictures by using image pictures from adjacent viewpoints through inter-view prediction. For example, a B picture **1213** captured from a second viewpoint S**1** at the point of time T**0** is bi-directionally predicted using the I picture **1211** from the viewpoint S**1** and a P picture **1212** from the viewpoint S**2**, which are adjacent viewpoints.

When image pictures from all the viewpoints in the columns **1210** and **1220** are each encoded using at least one from the I pictures, the B pictures, and the P pictures, the non-anchor pictures **1230** are bi-directionally prediction-encoded through temporal prediction using hierarchical B pictures and inter-view prediction, as described above.

Among the non-anchor pictures, the pictures captured from the odd-numbered viewpoints S**2**, S**4**, and S**6** and the last viewpoint S**7** are each bi-directionally prediction-encoded using anchor pictures from the same viewpoint through temporal prediction using hierarchical B pictures. Among the non-anchor pictures **1230**, the image pictures captured from the even-numbered viewpoints S**1**, S**3**, S**5**, and S**7** are bi-directionally prediction-encoded using not only through temporal prediction using hierarchical B pictures but also through inter-view prediction using pictures from adjacent viewpoints. For example, a picture **1236** captured from the viewpoint S**2** at the point of time T**4** is predicted using the anchor pictures **1213** and **1223** and pictures **1231** and **1235** from adjacent viewpoints.

The P pictures included in the columns **1210** and **1220** are each prediction-encoded using either an I picture captured from a different viewpoint at the same point of time or a previous P picture, as described above. For example, a P picture **1222** captured from the viewpoint S**2** at the last point of time T**8** is prediction-encoded using the I picture **1221** captured from the first viewpoint S**0** at the last point of time T**8**, as a reference picture.

A video encoding method and apparatus capable of prediction-encoding prediction units and partitions based on coding units having a tree structure, and a video decoding method and apparatus capable of prediction-decoding prediction units and partitions based on coding units having a tree structure will now be described in detail with reference to FIGS. **13** to **25**. The video encoding method and apparatus which will be described below may be applied to the color video frame encoding unit **320** of FIG. **3**, and the video decoding method and apparatus which will be described below may be applied to the color video frame decoding unit **920** of FIG. **9**.

FIG. **13** is a block diagram of a video encoding apparatus **100** capable of performing video prediction based on coding units having a tree structure, according to an exemplary embodiment.

The video encoding apparatus **1300** capable of performing video prediction based on coding units having a tree structure includes a maximum coding unit splitter **1310**, a coding unit determiner **1320**, and an output unit **1330** (e.g., an output).

For convenience of explanation, the video encoding apparatus **1300** capable of performing video prediction based on coding units having a tree structure will be hereinafter referred to as 'the video encoding apparatus **1300**'.

The maximum coding unit splitter **1310** may split a current picture of an image based on a maximum coding unit for the current picture. If the current picture is larger than the maximum coding unit, image data of the current picture may be split into at least one maximum coding unit. The maximum coding unit according to an exemplary embodiment may be a data unit having a size of 32×32, 64×64, 128×128, 256×256, etc., wherein a shape of the data unit is a square having a width and length in squares of 2. The image data may be output to the coding unit determiner **1320** according to the at least one maximum coding unit.

A coding unit according to an exemplary embodiment may be characterized by a maximum size and a depth. The depth denotes a number of times the coding unit is spatially split from the maximum coding unit, and as the depth deepens, coding units corresponding to depths may be split from the maximum coding unit to a minimum coding unit. A depth of the maximum coding unit may be determined as an uppermost depth, and the minimum coding unit may be determined as a lowermost coding unit. Since a size of a coding unit corresponding to each depth decreases as the depth of the maximum coding unit deepens, a coding unit corresponding to an upper depth may include a plurality of coding units corresponding to lower depths.

As described above, the image data of the current picture is split into the maximum coding units according to a maximum size of the coding unit, and each of the maximum coding units may include coding units that are split according to depths. Since the maximum coding unit according to an exemplary embodiment is split according to depths, the image data of a spatial domain included in the maximum coding unit may be hierarchically classified according to the depths.

A maximum depth and a maximum size of a coding unit, which limit the total number of times a height and a width of the maximum coding unit are hierarchically split, may be predetermined.

The coding unit determiner **1320** encodes at least one split region obtained by splitting a region of the maximum coding unit according to depths, and determines a depth to output a finally encoded image data according to the at least one split region. In other words, the coding unit determiner **1320** determines a coded depth by encoding the image data in the coding units corresponding to depths in units of the maximum coding units of the current picture, and selecting a depth having the least encoding error. The determined coded depth and the image data in each of the maximum coding units are output to the output unit **1330**.

The image data in each of the maximum coding units is encoded based on the coding units corresponding to depths, according to at least one depth equal to or below the maximum depth, and results of encoding the image data based on the coding units corresponding to depths are compared. A depth having the least encoding error may be selected after comparing encoding errors of the coding units corresponding to depths. At least one coded depth may be selected for each of the maximum coding units.

The size of the maximum coding unit is split as a coding unit is hierarchically split according to depths, and the number of coding units increases. Also, even if coding units included in one maximum coding unit correspond to the same depth, whether each of the coding units will be split to a lower depth is determined by measuring an encoding error of the image data of each of the coding units. Thus, since even data included in one maximum coding unit has a different encoding error corresponding to a depth, according to the location of the data, a coded depth may be differently set according to the location of the data. Accordingly, at least one coded depth may be set for one maximum coding unit, and the image data of the maximum coding unit may be divided according to coding units of the at least one coded depth.

Accordingly, the coding unit determiner **1320** according to an exemplary embodiment may determine coding units having a tree structure included in a current maximum coding unit. The 'coding units having a tree structure' according to an exemplary embodiment include coding units corresponding to a depth determined to be the coded depth, from among all coding units corresponding to depths included in the current maximum coding unit. Coding units corresponding to a coded depth may be hierarchically determined according to depths in the same region of the maximum coding unit, and may be independently determined in different regions of the maximum coding unit. Similarly, a coded depth in a current region may be independently determined from a coded depth in another region.

A maximum depth according to an exemplary embodiment is an index related to the number of splitting times from a maximum coding unit to a minimum coding unit. A first maximum depth according to an exemplary embodiment may denote the total number of splitting times from the maximum coding unit to the minimum coding unit. A second maximum depth according to an exemplary embodiment may denote the total number of depth levels from the maximum coding unit to the minimum coding unit. For example, when a depth of the maximum coding unit is 0, a depth of a coding unit obtained by splitting the maximum coding unit once may be set to 1, and a depth of a coding unit obtained by splitting the maximum coding unit twice may be set to 2. If a coding unit obtained by splitting the maximum coding unit four times is the minimum coding unit, then depth levels of depths 0, 1, 2, 3 and 4 exist. Thus, the first maximum depth may be set to 4, and the second maximum depth may be set to 5.

Prediction-encoding and transformation may be performed on the maximum coding unit. Similarly, prediction-encoding and transformation are performed in units of maximum coding units, based on coding units corresponding to depths and according to depths equal to or less than the maximum depth.

Since the number of coding units corresponding to depths increases whenever the maximum coding unit is split according to depths, encoding including prediction-encoding and transformation should be performed on all of the coding units corresponding to depths generated as a depth deepens. For convenience of explanation, prediction-encoding and transformation will now be described based on a coding unit of a current depth, included in at least one maximum coding unit.

The video encoding apparatus **1300** may variously select a size or shape of a data unit for encoding image data. In order to encode the image data, operations, such as prediction-encoding, transformation, and entropy encoding, are performed. At this time, the same data unit may be used for the all operations or different data units may be used for each operation.

For example, the video encoding apparatus **1300** may select not only a coding unit for encoding the image data, but also a data unit different from the coding unit so as to perform prediction-encoding on image data in the coding unit.

In order to prediction-encode the maximum coding unit, prediction-encoding may be performed based on a coding unit corresponding to a coded depth, i.e., based on a coding unit that is no longer split to coding units corresponding to a

lower depth. Hereinafter, the coding unit that is no longer split and becomes a basis unit for prediction-encoding will now be referred to as a 'prediction unit'. Partitions obtained by splitting the prediction unit may include a data unit obtained by splitting at least one of a height and a width of the prediction unit. The partitions may be data units obtained by splitting a prediction unit of a coding unit, and the prediction unit may be a partition having the same size as that of the coding unit.

For example, when a coding unit of 2N×2N (where N is a positive integer) is no longer split, this coding unit becomes a prediction unit of 2N×2N, and a size of a partition may be 2N×2N, 2N×N, N×2N, or N×N. Examples of a partition type include symmetrical partitions that are obtained by symmetrically splitting a height or width of the prediction unit, partitions obtained by asymmetrically splitting the height or width of the prediction unit, such as 1:n or n:1, partitions that are obtained by geometrically splitting the prediction unit, and partitions having arbitrary shapes.

A prediction mode of the prediction unit may be at least one of an intra mode, a inter mode, and a skip mode. For example, the intra mode or the inter mode may be performed on partition of 2N×2N, 2N×N, N×2N, or N×N. Also, the skip mode may be performed only on a partition of 2N×2N. Encoding may be independently performed on one prediction unit in each coding unit, and a prediction mode having a least encoding error may be selected.

Also, the video encoding apparatus **1300** may perform transformation on the image data in a coding unit based not only on the coding unit for encoding the image data, but also based on a data unit that is different from the coding unit. In order to perform transformation on the coding unit, transformation may be performed based on a data unit having a size smaller than or equal to that of the coding unit. For example, transformation units may include a data unit for the intra mode and a data unit for the inter mode.

Similarly to coding units having a tree structure according to an exemplary embodiment, a transformation unit in a coding unit may be recursively split into smaller sized transformation units. Thus, residual data in the coding unit may be divided according to transformation units having a tree structure according to transformation depths.

A transformation unit according to an exemplary embodiment may also be assigned a transformation depth denoting a number of times the height and width of a coding unit are split to obtain the transformation unit. For example, a transformation depth may be 0 when a size of a transformation unit for a 2N×2N current coding unit is 2N×2N, a transformation depth may be 1 when a size of a transformation unit for the 2N×2N current coding unit is N×N, and a transformation depth may be 2 when a size of a transformation unit for the 2N×2N current coding unit is N/2×N/2. That is, transformation units having a tree structure may also be set according to transformation depths.

Encoding information for each coded depth requires not only information about the coded depth, but also about information related to prediction-encoding and transformation. Accordingly, the coding unit determiner **1320** may not only determine a coded depth having a least encoding error, but also determine a partition type in a prediction unit, a prediction mode for each prediction unit, and a size of a transformation unit for transformation.

Coding units having a tree structure included in a maximum coding unit and a method of determining a prediction unit/partition and a transformation unit, according to exemplary embodiments, will be described in detail later.

The coding unit determiner **1320** may measure encoding errors of coding units corresponding to depths by using Rate-Distortion Optimization based on Lagrangian multipliers.

The output unit **1330** outputs the image data of the maximum coding unit, which is encoded based on the at least one coded depth determined by the coding unit determiner **1320**, and information about the encoding mode of each of depths, in a bitstream.

The encoded image data may be a result of encoding residual data of an image.

The information about the encoding mode of each of depths may include information about the coded depth, about the partition type in the prediction unit, the prediction mode, and the size of the transformation unit.

The information about the coded depth may be defined using split information according to depths, which indicates whether encoding is to be performed on coding units of a lower depth instead of a current depth. If a current depth of a current coding unit is the coded depth, then the current coding unit is encoded using coding units corresponding to the current depth, and split information about the current depth may thus be defined such that the current coding unit of the current depth may not split any longer into coding units of a lower depth. Reversely, if the current depth of the current coding unit is not the coded depth, then coding units of a lower depth should be encoded and the split information about the current depth may thus be defined such that the current coding unit of the current depth may split into coding units of a lower depth.

If the current depth is not the coded depth, encoding is performed on the coding units of the lower depth. Since at least one coding unit of the lower depth exists in one coding unit of the current depth, encoding is repeatedly performed on each coding unit of the lower depth, and coding units having the same depth may thus be recursively encoded.

Since coding units having a tree structure should be determined in one maximum coding unit and information about at least one encoding mode is determined for each coding unit of a coded depth, information about at least one encoding mode may be determined for one maximum coding unit. Also, image data of the maximum coding unit may have a different coded depth according to the location thereof since the image data is hierarchically split according to depths. Thus, information about a coded depth and an encoding mode may be set for the image data.

Accordingly, the output unit **1330** according to an exemplary embodiment may assign encoding information about a corresponding coded depth and an encoding mode to at least one of coding units, prediction units, and a minimum unit included in the maximum coding unit.

The minimum unit according to an exemplary embodiment is a rectangular data unit obtained by splitting a minimum coding unit of a lowermost depth by 4. Alternatively, the minimum unit may be a maximum rectangular data unit that may be included in all of the coding units, prediction units, partition units, and transformation units included in the maximum coding unit.

For example, encoding information output via the output unit **1330** may be classified into encoding information of each of coding units corresponding to depths, and encoding information of each of prediction units. The encoding information of each of coding units corresponding to depths may include prediction mode information and partition size information. The encoding information of each of prediction units may include information about an estimated direction of an inter mode, about a reference image index of the inter mode, about a motion vector, about a chroma component of the intra mode, and about an interpolation method of an intra mode.

Information about a maximum size of coding units defined in units of pictures, slices, or GOPs, and information about a maximum depth may be inserted into a header of a bitstream, a sequence parameter set (SPS) or a Picture parameter set (PPS).

Also, information about a maximum size and a minimum size of a transformation unit available in a current video may be transmitted via a header of a bitstream, an SPS, or a PPS. The output unit **1330** may encode and output information about scalability of coding units.

In the video encoding apparatus **1300** according to an exemplary embodiment, coding units corresponding to depths may be coding units obtained by dividing a height or width of a coding unit of an upper depth by two. In other words, when the size of a coding unit of a current depth is 2N×2N, the size of a coding unit of a lower depth is N×N. Also, the 2N×2N coding unit may include four N×N coding units of the lower depth at most.

Accordingly, the video encoding apparatus **1300** may form coding units having a tree structure by determining coding units having an optimum shape and size for each maximum coding unit, based on the size of each maximum coding unit and a maximum depth determined considering characteristics of a current picture. Also, since each maximum coding unit may be encoded according to any one of various prediction modes and transformation methods, an optimum encoding mode may be determined considering characteristics of coding units of various image sizes.

Thus, if an image having very high resolution or very large data amount is encoded in units of related art macroblocks, a number of macroblocks per picture excessively increases. Thus, an amount of compressed information generated for each macroblock increases, and thus it is difficult to transmit the compressed information and data compression efficiency decreases. However, the video encoding apparatus **1300** is capable of controlling a coding unit based on characteristics of an image while increasing a maximum size of the coding unit in consideration of a size of the image, thereby increasing image compression efficiency.

FIG. **14** is a block diagram of a video decoding apparatus **1400** capable of performing video prediction based on coding units having a tree structure, according to an exemplary embodiment.

The video decoding apparatus **1400** capable of performing video prediction based on coding units having a tree structure includes a receiver **1410**, an image data and encoding information extractor **1420**, and an image data decoder **1430**. For convenience of explanation, the video decoding apparatus **1400** capable of performing video prediction based on coding units having a tree structure will now be referred to as 'video decoding apparatus **1400**'.

Definitions of various terms, such as a coding unit, a depth, a prediction unit, a transformation unit, and information about various encoding modes, which are used below to explain decoding operations of the video decoding apparatus **1400**, are identical to those of the video encoding apparatus **1300** described above with reference to FIG. **13**.

The receiver **1410** receives and parses a bitstream of an encoded video. The image data and encoding information extractor **1420** extracts encoded image data for each of coding units having a tree structure in units of maximum coding units, from the parsed bitstream, and then outputs the extracted image data to the image data decoder **1430**. The image data and encoding information extractor **1420** may extract information about a maximum size of coding units of a current picture, from a header regarding the current picture, an SPS, or a PPS.

Also, the image data and encoding information extractor **1420** extracts information about a coded depth and an encoding mode for the coding units having the tree structure in units of the maximum coding unit, from the parsed bitstream. The extracted information about the coded depth and the encoding mode is output to the image data decoder **1430**. In other words, the image data in the bitstream may be split into the maximum coding units so that the image data decoder **1430** may decode the image data in units of the maximum coding units.

The information about the coded depth and the encoding mode for each of the maximum coding units may be set for information about at least one coded depth. The information about the encoding mode for each coded depth may include information about a partition type of a corresponding coding unit corresponding to coded depth, about a prediction mode, and a size of a transformation unit. Also, splitting information according to depths may be extracted as the information about the coded depth.

The information about the coded depth and the encoding mode for each of the maximum coding units extracted by the image data and encoding information extractor **1420** is information about a coded depth and an encoding mode determined to generate a minimum encoding error when an encoding side, e.g., the video encoding apparatus **1300**, repeatedly encodes each of coding units corresponding to depths in units of maximum coding units. Accordingly, the video decoding apparatus **1400** may restore an image by decoding the image data according to a coded depth and an encoding mode that generates the minimum encoding error.

Since encoding information about the coded depth and the encoding mode may be assigned to data units from among corresponding coding units, prediction units, and a minimum unit, the image data and encoding information extractor **1420** may extract the information about the coded depth and the encoding mode in units of the data units. If the information about the coded depth and the encoding mode for each of the maximum coding units is recorded in units of the data units, data units including information about the same coded depth and encoding mode may be inferred to as data units included in the same maximum coding unit.

The image data decoder **1430** restores the current picture by decoding the image data in each of the maximum coding units, based on the information about the coded depth and the encoding mode for each of the maximum coding units. In other words, the image data decoder **1430** may decode the encoded image data based on parsed partition type, prediction mode, and transformation unit for each of the coding units having the tree structure included in each of the maximum coding units. A decoding process may include a prediction process including intra prediction and motion compensation, and an inverse transformation process.

The image data decoder **1430** may perform intra prediction or motion compensation on each of the coding units according to partitions and a prediction mode thereof, based on the information about the partition type and the prediction mode of prediction units of each of coding units according to coded depths.

Also, in order to perform inverse transformation on each of the maximum coding units, the image data decoder **1430** may parse information about transformation units having a tree structure of each of the coding units and perform inverse transformation based on the transformation units of each of the coding units. Through inverse transformation, pixel values of a spatial domain of each of the coding units may be restored.

The image data decoder **1430** may determine a coded depth of a current maximum coding unit, based on split information according to depths. If the split information indicates that image data is no longer split in the current depth, the current depth is a coded depth. Thus, the image data decoder **1430** may decode image data of a current maximum coding unit by using the information about the partition type of the prediction unit, the prediction mode, and the size of the transformation unit of a coding unit corresponding to a current depth.

In other words, data units containing encoding information including the same split information may be gathered by observing encoding information assigned to a data unit from among the coding unit, the prediction unit, and the minimum unit, and the gathered data units may be considered as one data unit to be decoded according to the same encoding mode by the image data decoder **1430**.

The video decoding apparatus **1400** may obtain information about a coding unit that generates a least encoding error by recursively encoding each of the maximum coding units, and may use the information to decode the current picture. In other words, the encoded image data in the coding units having the tree structure determined to be optimum coding units in units of the maximum coding units may be decoded.

Accordingly, even if image data has high resolution and a very large amount of data, the image data may be efficiently decoded to be restored by using a size of a coding unit and an encoding mode, which are adaptively determined according to characteristics of the image data, based on information about an optimum encoding mode received from an encoding side.

FIG. **15** illustrates a concept of coding units according to an exemplary embodiment.

A size of a coding unit may be expressed in width×height, and may be 64×64, 32×32, 16×16, and 8×8. A coding unit of 64×64 may be split into partitions of 64×64, 64×32, 32×64, or 32×32, and a coding unit of 32×32 may be split into partitions of 32×32, 32×16, 16×32, or 16×16, a coding unit of 16×16 may be split into partitions of 16×16, 16×8, 8×16, or 8×8, and a coding unit of 8×8 may be split into partitions of 8×8, 8×4, 4×8, or 4×4.

In video data **1510**, a resolution is 1920×1080, a maximum size of a coding unit is 64, and a maximum depth is 2. In video data **1520**, a resolution is 1920×1080, a maximum size of a coding unit is 64, and a maximum depth is 3. In video data **1530**, a resolution is 352×288, a maximum size of a coding unit is 16, and a maximum depth is 1. The maximum depth shown in FIG. **15** denotes a total number of splits from a maximum coding unit to a minimum decoding unit.

If a resolution is high or an amount of data is large, a maximum size of a coding unit may be relatively large so as to not only increase encoding efficiency but also to accurately reflect characteristics of an image. Accordingly, the maximum size of the coding unit of the video data **1510** and **1520** having the higher resolution than the video data **330** may be 64.

Since the maximum depth of the video data **1510** is 2, coding units **1515** of the vide data **1510** may include a maximum coding unit having a long axis size of 64, and coding units having long axis sizes of 32 and 16 since depths are deepened to two layers by splitting the maximum coding unit twice. Meanwhile, since the maximum depth of the video data **1530** is 1, coding units **1535** of the video data **1530** may include a maximum coding unit having a long axis size of 16, and coding units having a long axis size of 8 since depths are deepened to one layer by splitting the maximum coding unit once.

Since the maximum depth of the video data **1520** is 3, coding units **1525** of the video data **1520** may include a maximum coding unit having a long axis size of 64, and coding units having long axis sizes of 32, 16, and 8 since the depths are deepened to 3 layers by splitting the maximum coding unit three times. As a depth deepens, detailed information may be precisely expressed.

FIG. **16** is a block diagram of an image encoder **400** based on coding units, according to an exemplary embodiment.

The image encoder **1600** performs operations of the coding unit determiner **1320** of the video encoding apparatus **1300** to encode image data. Specifically, an intra predictor **1610** performs intra prediction on coding units in an intra mode from among a current frame **1605**, and a motion estimator **1620** and a motion compensator **1625** performs inter estimation and motion compensation on coding units in an inter mode from among the current frame **1605** by using the current frame **1605** and a reference frame **1695**.

Data output from the intra predictor **1610**, the motion estimator **1620**, and the motion compensator **1625** is output as a quantized transformation coefficient through a transformer **1630** and a quantizer **1640**. The quantized transformation coefficient is restored as data in a spatial domain through an inverse quantizer **1660** and an inverse transformer **1670**. The restored data in the spatial domain is output as the reference frame **1695** after being post-processed through a deblocking unit **1680** and a loop filtering unit **1690**. The quantized transformation coefficient may be output in a bitstream **1655** through an entropy encoder **1650**.

In order to apply the image encoder **1600** to the video encoding apparatus **1300**, all elements of the image encoder **1600**, i.e., the intra predictor **1610**, the motion estimator **1620**, the motion compensator **1625**, the transformer **1630**, the quantizer **1640**, the entropy encoder **1650**, the inverse quantizer **1660**, the inverse transformer **1670**, the deblocking unit **1680**, and the loop filtering unit **1690** perform operations based on each coding unit from among coding units having a tree structure while considering the maximum depth of each maximum coding unit.

Particularly, the intra predictor **1610**, the motion estimator **1620**, and the motion compensator **1625** determine partitions and a prediction mode of each coding unit from among the coding units having the tree structure while considering the maximum size and the maximum depth of a current maximum coding unit. The transformer **1630** determines the size of the transformation unit in each coding unit from among the coding units having the tree structure.

FIG. **17** is a block diagram of an image decoder **1700** based on coding units, according to an exemplary embodiment.

A parser **1710** parses a bitstream **1705** to obtain encoded image data to be decoded and encoding information required to decode the encoded image data. The encoded image data is output as inversely quantized data through an entropy decoder **1720** and an inverse quantizer **1730**, and the inverse quantized data is restored to image data in a spatial domain through an inverse transformer **1740**.

With respect to the image data in the spatial domain, an intra predictor **1750** performs intra prediction on coding units in an intra mode, and a motion compensator **1760** performs motion compensation on coding units in an inter mode by using a reference frame **1785**.

The image data in the spatial domain, which passed through the intra predictor **1750** and the motion compensator **1760**, may be output as a restored frame **1795** after being post-processed through a deblocking unit **1770** (e.g., a deblocker) and a loop filtering unit **1780** (e.g., a loop filterer). Also, the image data that is post-processed through the

deblocking unit **1770** and the loop filtering unit **1780** may be output as the reference frame **1785**.

In order to decode the image data by using the image data decoder **1430** of the video decoding apparatus **1400**, the image decoder **1700** may perform operations that are performed after an operation of the parser **1710**.

In order to apply the image decoder **1700** to the video decoding apparatus **1400**, all elements of the image decoder **1700**, i.e., the parser **1710**, the entropy decoder **1720**, the inverse quantizer **1730**, the inverse transformer **1740**, the intra predictor **1750**, the motion compensator **1760**, the deblocking unit **1770**, and the loop filtering unit **1780** perform operations based on coding units having a tree structure, in units of maximum coding units.

Particularly, the intra prediction **1750** and the motion compensator **1760** determine partitions and a prediction mode for each of the coding units having the tree structure, and the inverse transformer **1740** determines a size of a transformation unit for each of the coding units.

FIG. **18** is a diagram illustrating coding units corresponding to depths, and partitions, according to an exemplary embodiment.

The video encoding apparatus **1300** and the video decoding apparatus **1400** according to an exemplary embodiment use hierarchical coding units to consider characteristics of an image. A maximum height, a maximum width, and a maximum depth of a coding unit may be adaptively determined according to the characteristics of the image, or may be differently set by a user. Sizes of coding units corresponding to depths may be determined according to the predetermined maximum size of the coding unit.

In a hierarchical structure **1800** of coding units according to an exemplary embodiment, the maximum height and the maximum width of the coding units are each 64, and the maximum depth is 4. The maximum depth denotes a total number of splitting times from a maximum coding unit to a minimum coding unit. Since a depth deepens along a vertical axis of the hierarchical structure **1800**, a height and width of each of coding units corresponding to depths are each split. Also, a prediction unit and partitions, which are bases for prediction-encoding each of the coding units corresponding to depths, are shown along a horizontal axis of the hierarchical structure **1800**.

Specifically, in the hierarchical structure **1800**, a coding unit **1810** is a maximum coding unit, and has a depth is 0 and a size of 64×64 (height×width). As depth deepens along the vertical axis, a coding unit **1820** having a size of 32×32 and a depth of 1, a coding unit **1830** having a size of 16×16 and a depth of 2, a coding unit **1840** having a size of 8×8 and a depth of 3, and a coding unit **1850** having a size of 4×4 and a depth of 4 exist. The coding unit **1850** having the size of 4×4 and the depth of 4 is a minimum coding unit.

A prediction unit and partitions of each coding unit are arranged along the horizontal axis according to each depth. If the coding unit **1810** having the size of 64×64 and the depth of 0 is a prediction unit, the prediction unit may be split into partitions included in the coding unit **1810**, i.e. a partition **1810** having a size of 64×64, partitions **1812** having a size of 64×32, partitions **1814** having a size of 32×64, or partitions **1816** having a size of 32×32.

Similarly, a prediction unit of the coding unit **1820** having the size of 32×32 and the depth of 1 may be split into partitions included in the coding unit **1820**, i.e. a partition **1820** having a size of 32×32, partitions **1822** having a size of 32×16, partitions **1824** having a size of 16×32, and partitions **1826** having a size of 16×16.

Similarly, a prediction unit of the coding unit **1830** having the size of 16×16 and the depth of 2 may be split into partitions included in the coding unit **1830**, i.e. a partition **1830** having a size of 16×16, partitions **1832** having a size of 16×8, partitions **1834** having a size of 8×16, and partitions **1836** having a size of 8×8.

Similarly, a prediction unit of the coding unit **1840** having the size of 8×8 and the depth of 3 may be split into partitions included in the coding unit **1840**, i.e. a partition **1840** having a size of 8×8, partitions **1842** having a size of 8×4, partitions **1844** having a size of 4×8, and partitions **1846** having a size of 4×4.

The coding unit **1850** having the size of 4×4 and the depth of 4 is the minimum coding unit having a lowermost depth. A prediction unit of the coding unit **1850** is set to only a partition **1850** having a size of 4×4.

In order to determine a coded depth of the maximum coding unit **1810**, the coding unit determiner **1320** of the video encoding apparatus **1300** encodes all coding units corresponding to each depth, included in the maximum coding unit **1810**.

As depth increases, a number of coding units, which correspond to each depth and include data having the same range and the same size, increases. For example, four coding units corresponding to a depth of 2 are required to cover data included in one coding unit corresponding to a depth of 1. Accordingly, in order to compare results of encoding the same data according to depths, the coding unit corresponding to the depth of 1 and the four coding units corresponding to the depth of 2 are each encoded.

In order to perform encoding in units of depths, a least encoding error of each of the depths may be selected as a representative encoding error by encoding prediction units in each of the coding units corresponding to the depths, along the horizontal axis of the hierarchical structure **1800**. Alternatively, a least encoding error may be searched for by performing encoding in units of depths and comparing least encoding errors according to the depths, as the depth deepens along the vertical axis of the hierarchical structure **1800**. A depth and a partition having the least encoding error in the maximum coding unit **1810** may be selected as a coded depth and a partition type of the maximum coding unit **1810**.

FIG. **19** is a diagram illustrating a correlation between a coding unit **1910** and transformation units **1920**, according to an exemplary embodiment.

The video encoding apparatus **1300** (or the video decoding apparatus **1400**) according to an exemplary embodiment encodes (or decodes) an image in units of maximum coding units, based on coding units having sizes smaller than or equal to the maximum coding units. During the encoding, a size of each transformation unit used to perform transformation may be selected based on a data unit that is not larger than a corresponding coding unit.

For example, in the video encoding apparatus **1300** (or the video decoding apparatus **1400**), if a size of the coding unit **1910** is 64×64, transformation may be performed using the transformation units **1920** having a size of 32×32.

Also, data of the coding unit **1910** having the size of 64×64 may be encoded by performing transformation on each of transformation units having a size of 32×32, 16×16, 8×8, and 4×4, which are smaller than 64×64, and then a transformation unit having a least coding error may be selected.

FIG. **20** is a diagram illustrating encoding information corresponding to depths, according to an exemplary embodiment.

The output unit **1330** of the video encoding apparatus **1300** may encode and transmit information **2000** about a partition

type, information **2010** about a prediction mode, and information **2020** about transformation unit size for each coding unit corresponding to a coded depth, as information about an encoding mode.

The information **2000** indicates information about a shape of a partition obtained by splitting a prediction unit of a current coding unit, as a data unit for prediction-encoding the current coding unit. For example, a current coding unit CU_0 having a size of 2N×2N may be split into any one of a partition **2002** having a size of 2N×2N, a partition **2004** having a size of 2N×N, a partition **2006** having a size of N×2N, and a partition **2008** having a size of N×N. In this case, the information **2000** is set to indicate one of the partition **2004** having a size of 2N×N, the partition **2006** having a size of N×2N, and the partition **2008** having a size of N×N

The information **2010** indicates a prediction mode of each partition. For example, the information **2010** may indicate a mode of prediction-encoding the partition indicated by the information **2000**, i.e., an intra mode **2012**, an inter mode **2014**, or a skip mode **2016**.

The information **2020** indicates a transformation unit to be based on when transformation is performed on a current coding unit. For example, the transformation unit may be a first intra transformation unit **2022**, a second intra transformation unit **2024**, a first inter transformation unit **2026**, or a second intra transformation unit **828**.

The image data and encoding information extractor **1420** of the video decoding apparatus **1400** may extract and use the information **2000**, **2010**, and **2020** for decoding coding units corresponding to depths.

FIG. **21** is a diagram illustrating coding units corresponding to depths, according to an exemplary embodiment.

Split information may be used to indicate a depth change. The spilt information indicates whether a coding unit of a current depth is split into coding units of a lower depth.

A prediction unit **2110** for prediction-encoding a coding unit **2100** having a depth of 0 and a size of 2N_0×2N_0 may include partitions of a partition type **2112** having a size of 2N_0×2N_0, a partition type **2114** having a size of 2N_0×N_0, a partition type **2116** having a size of N_0×2N_0, and a partition type **2118** having a size of N_0×N_0. Although FIG. **9** illustrates only the partition types **2112** through **2118** which are obtained by symmetrically splitting the prediction unit **2110**, a partition type is not limited thereto, and the partitions of the prediction unit **2110** may include asymmetrical partitions, partitions having an arbitrary shape, and partitions having a geometrical shape.

Prediction-encoding is repeatedly performed on one partition having a size of 2N_0×2N_0, two partitions having a size of 2N_0×N_0, two partitions having a size of N_0×2N_0, and four partitions having a size of N_0×N_0, according to each partition type. Prediction-encoding may be performed on the partitions having the sizes of 2N_0×2N_0, N_0×2N_0, 2N_0×N_0, and N_0×N_0, according to an intra mode and an inter mode. Prediction-encoding is performed only on the partition having the size of 2N_0×2N_0, according to a skip mode.

If an encoding error is smallest in one of the partition types **2112** through **2116**, the prediction unit **2110** may not be split into a lower depth.

If an encoding error is the smallest in the partition type **2118**, a depth is changed from 0 to 1 to split the partition type **2118** in operation **2120**, and encoding is repeatedly performed on coding units **2130** having partitions of a depth of 2 and a size of N_0×N_0 to search for a minimum encoding error.

A prediction unit **2140** for prediction-encoding the coding unit **2130** having a depth of 1 and a size of 2N_1×2N_1 (=N_0×N_0) may include partitions of a partition type **2142** having a size of 2N_1×2N_1, a partition type **2144** having a size of 2N_1×N_1, a partition type **2146** having a size of N_1×2N_1, and a partition type **2148** having a size of N_1×N_1.

If an encoding error is the smallest in the partition type **2148** having a size of N_1×N_1, a depth is changed from 1 to 2 to split the partition type **2148** in operation **2150**, and encoding is repeatedly performed on coding units **2160** having a depth of 2 and a size of N_2×N_2 so as to search for a minimum encoding error.

When a maximum depth is d, coding units corresponding to depths may be set up to when a depth becomes d−1, and split information may be set up to when a depth is d−2. In other words, when encoding is performed up to when the depth is d−1 after a coding unit corresponding to a depth of d−2 is split in operation **2170**, a prediction unit **2190** for prediction-encoding a coding unit **2180** having a depth of d−1 and a size of 2N_(d−1)×2N_(d−1) may include partitions of a partition type **992** having a size of 2N_(d−1)×2N_(d−1), a partition type **2194** having a size of 2N_(d−1)×N_(d−1), a partition type **2196** having a size of N_(d−1)×2N_(d−1), and a partition type **2198** having a size of N_(d−1)×N_(d−1).

Prediction-encoding may be repeatedly performed on one partition having a size of 2N_(d−1)×2N_(d−1), two partitions having a size of 2N_(d−1)×N_(d−1), two partitions having a size of N_(d−1)×2N_(d−1), and four partitions having a size of N_(d−1)×N_(d−1) from among the partition types **2192** through **2198** so as to search for a partition type having a minimum encoding error.

Even when the partition type **2198** has the minimum encoding error, since a maximum depth is d, a coding unit CU_(d−1) having a depth of d−1 is no longer split to a lower depth, and a coded depth for a current maximum coding unit **2100** is determined to be d−1 and a partition type of the coding unit **2100** may be determined to be N_(d−1)×N_(d−1). Also, since the maximum depth is d, split information is not set for a coding unit **952** having a depth of (d−1).

A data unit **2199** may be a 'minimum unit' for the current maximum coding unit **2100**. A minimum unit according to an exemplary embodiment may be a rectangular data unit obtained by splitting a minimum unit having a lowest coded depth by 4. By performing encoding repeatedly as described above, the video encoding apparatus **1300** may determine a coded depth by comparing encoding errors according to depths of the coding unit **2100** and selecting a depth having the least encoding error, and set a partition type and a prediction mode for the coding unit **2100** as an encoding mode of the coded depth.

As such, minimum encoding errors according to depths, i.e., the depths of 0, 1, . . . , d−1, and d, are compared with one another, and a depth having the least encoding error may be determined as a coded depth. The coded depth, the partition type of the prediction unit, and the prediction mode may be encoded and transmitted as information about an encoding mode. Also, since a coding unit is split from the depth of 0 to the coded depth, only split information of the coded depth is set to 0, and split information of the other depths excluding the coded depth is set to 1.

The image data and encoding information extractor **1420** of the video decoding apparatus **1400** may extract and use the information about the coded depth and the prediction unit of the coding unit **2100** to decode the partition **2112**. The video decoding apparatus **1400** may determine a depth corresponding to split information '0', as a coded depth, based on split information according to depths, and may use information an encoding mode about the coded depth during a decoding process.

FIGS. **22**, **23**, and **24** are diagrams illustrating a correlation between coding units **2210**, prediction units **2260**, and transformation units **2270**, according to an exemplary embodiment.

The coding units **2210** are coding units corresponding to coded depths for a maximum coding unit, determined by the video encoding apparatus **1300**. The prediction units **2260** are partitions of prediction units of the respective coding units **2210**, and the transformation units **2270** are transformation units of the respective coding units **2210**.

Among the coding units **2210**, if a depth of a maximum coding unit is 0, then coding units **2212** and **2254** have a depth of 1, coding units **2214**, **2216**, **2218**, **2228**, **2250**, and **2252** have a depth of 2, coding units **2220**, **2222**, **2224**, **2226**, **2230**, **2232**, and **2248** have a depth of 3, and coding units **2240**, **2242**, **2244**, and **2246** have a depth of 4.

Among the prediction units **2260**, some partitions **2214**, **2216**, **2222**, **2232**, **2248**, **2250**, **2252**, and **2254** are split into partitions split from coding units. In other words, the partitions **2214**, **2222**, **2250**, and **2254** are 2N×N partition types, partitions **2216**, **2248**, and **2252** are N×2N partition types, and the partition **2232** is a N×N partition type. Prediction units and partitions of the coding units **2210** are smaller than or equal to coding units corresponding thereto.

Among the transformation units **2270**, transformation or inverse transformation is performed on image data corresponding to coding unit **2252**, based on a data unit that is smaller than the coding unit **2252**. Also, transformation units **2214**, **2216**, **2222**, **2232**, **2248**, **2250**, **2252**, and **2254** are data units different from corresponding prediction units and partitions among the prediction units **2260**, in terms of sizes and shapes. In other words, the video encoding apparatus **1300** and the video decoding apparatus **1400** according to an exemplary embodiment may individually perform intra prediction, motion estimation, motion compensation, transformation, and inverse transformation on the same coding unit, based on different data units

Accordingly, an optimum coding unit may be determined by recursively encoding coding units having a hierarchical structure, in units of regions of each maximum coding unit, thereby obtaining coding units having a recursive tree structure. Encoding information may include split information about a coding unit, information about a partition type, information about a prediction mode, and information about a size of a transformation unit. Table 1 shows an example of encoding information that may be set by the video encoding apparatus **1300** and the video decoding apparatus **1400**.

The output unit **1330** of the video encoding apparatus **1300** may output the encoding information about the coding units having a tree structure, and the image data and encoding information extractor **1420** of the video decoding apparatus **1400** may extract the encoding information about the coding units having a tree structure from a received bitstream.

Split information indicates whether a current coding unit is split into coding units of a lower depth. If split information of a current depth d is 0, a depth, in which the current coding unit is no longer split into coding units of a lower depth, is a coded depth, and thus information about a partition type, a prediction mode, and a size of a transformation unit may be defined for the coded depth. If the current coding unit is further split according to the split information, encoding is independently performed on four split coding units of a lower depth.

The prediction mode may be one of an intra mode, an inter mode, and a skip mode. The intra mode and the inter mode may be defined for all partition types, and the skip mode is defined only for a 2N×2N partition type.

The information about the partition type may indicate symmetrical partition types having sizes of 2N×2N, 2N×N, N×2N, and N×N, which are obtained by symmetrically splitting a height or a width of a prediction unit, and asymmetrical partition types having sizes of 2N×nU, 2N×nD, nL×2N, and nR×2N, which are obtained by asymmetrically splitting the height or width of the prediction unit. The asymmetrical partition types having the sizes of 2N×nU and 2N×nD may be respectively obtained by splitting the height of the prediction unit in 1:3 and 3:1, and the asymmetrical partition types having the sizes of nL×2N and nR×2N may be respectively obtained by splitting the width of the prediction unit in 1:3 and 3:1.

The size of the transformation unit may be set to be two types in the intra mode and two types in the inter mode. In other words, if split information of the transformation unit is 0, the size of the transformation unit may be 2N×2N to be equal to the size of the current coding unit. If the split information of the transformation unit is 1, transformation units may be obtained by splitting the current coding unit. Also, a size of a transformation unit may be N×N when a partition type of the current coding unit having the size of 2N×2N is a symmetrical partition type, and may be N/2×N/2 when the partition type of the current coding unit is an asymmetrical partition type.

The encoding information about coding units having a tree structure may be assigned to at least one of a coding unit corresponding to a coded depth, a prediction unit, and a

TABLE 1

Split Information 0 (Encoding on Coding Unit having Size of 2N × 2N and Current Depth of d)					
	Partition Type		Size of Transformation Unit		
Prediction Mode	Symmetrical Partition Type	Asymmetrical Partition Type	Split Information 0 of Transformation Unit	Split Information 1 of Transformation Unit	Split Information 1
Intra Inter Skip (Only 2N × 2N)	2N × 2N 2N × N N × 2N N × N	2N × nU 2N × nD nL × 2N nR × 2N	2N × 2N	N × N (Symmetrical Type) N/2 × N/2 (Asymmetrical Type)	Repeatedly Encode Coding Units having Lower Depth of d + 1

minimum unit. The coding unit corresponding to the coded depth may include at least one prediction unit and at least one minimum unit that contain the same encoding information.

Accordingly, whether adjacent data units are included in coding units corresponding to the same coded depth may be determined by comparing encoding information of the adjacent data units. Also, a coding unit corresponding to a coded depth may be determined using encoding information of a data unit thereof. Thus, a distribution of coded depths in a maximum coding unit may be determined.

Accordingly, if the current coding unit is predicted based on encoding information of adjacent data units, encoding information of data units in coding units corresponding to depths adjacent to the current coding unit may be directly referred to and used.

Alternatively, if the current coding unit is predicted based adjacent coding units, then adjacent coding units may be referred to by searching data units adjacent to the current coding unit from coding units corresponding to depths, based on encoding information of adjacent coding units corresponding to depths.

FIG. **25** is a diagram illustrating a correlation between a coding unit, a prediction unit, and a transformation unit, according to encoding mode information of Table 1.

A maximum coding unit **2500** includes coding units **2502**, **2504**, **2506**, **2512**, **2514**, **2516**, and **2518** of coded depths. Here, since the coding unit **2518** is a coding unit of a coded depth, split information thereof may be set to 0. Information about a partition type of the coding unit **2518** having a size of 2N×2N may be set to be one of a partition type **2522** having a size of 2N×2N, a partition type **2524** having a size of 2N×N, a partition type **2526** having a size of N×2N, a partition type **2528** having a size of N×N, a partition type **2532** having a size of 2N×nU, a partition type **2534** having a size of 2N×nD, a partition type **2536** having a size of nL×2N, and a partition type **2538** having a size of nR×2N.

Transformation unit split information, i.e., a Tu size flag, is a type of a transformation index. The size of a transformation unit corresponding to the transformation index may vary according to a prediction unit type or a partition type of a coding unit.

For example, if the partition type is set to be a symmetrical partition type, e.g., the partition type **2522**, **2524**, **2526**, or **2528**, then a transformation unit **2542** having a size of 2N×2N is set when the TU size flag is '**0**', and a transformation unit **2544** having a size of N×N is set when the TU size flag is '**1**'.

If the partition type is set to be an asymmetrical partition type, e.g., the partition type **2532**, **2534**, **2536**, or **2538**, then a transformation unit **2552** having a size of 2N×2N is set when a TU size flag is **0**, and a transformation unit **2554** having a size of N/2×N/2 is set when a TU size flag is **1**.

By storing a program that executes a method of encoding multi-view video data and a method of decoding multi-view video data according to an exemplary embodiment described above with reference to FIGS. **1** to **25**, on a computer readable recording medium, an individual computer system may easily perform these methods.

For convenience of explanation, the method of encoding multi-view video data and the method of decoding multi-view video data described above with reference to FIGS. **1** to **25** will now be referred to as 'video encoding method according to an exemplary embodiment' and 'video decoding method according to an exemplary embodiment', respectively. Also, the multi-view video data encoding apparatus **300** and the multi-view video data decoding apparatus **900** described above with reference to FIGS. **1** to **25** will now be referred to as 'video encoding apparatus according to an exemplary embodiment' and 'video decoding apparatus according to an exemplary embodiment,' respectively.

A computer readable recording medium storing a program, e.g., a disc **260**, according to an exemplary embodiment will now be described in detail.

FIG. **26**A illustrates a physical structure of a disc **2600** that stores a program, according to an exemplary embodiment. The disc **2600** which is a storage medium may be a hard drive, a compact disc-read only memory (CD-ROM) disc, a Blu-ray disc, or a digital versatile disc (DVD). The disc **2600** includes a plurality of concentric tracks Tf each being divided into a specific number of sectors Se in a circumferential direction of the disc **2600**. In a specific region of the disc **2600**, a program that executes a method of predicting multi-view video, a method of prediction restoring multi-view video, a method of encoding multi-view video, and a method of decoding multi-view video as described above may be assigned and stored.

A computer system embodied using a storage medium that stores a program for executing a video encoding method and a video decoding method as described above will now be described with reference to FIG. **26**B.

FIG. **26**B illustrates a disc drive **2668** that records and reads a program by using a disc **2600**. A computer system **2667** may store a program that executes at least one of a video encoding method and a video decoding method according to an exemplary embodiment, in a disc **2600** via the disc drive **2668**. To run the program stored in the disc **2600** in the computer system **2667**, the program may be read from the disc **2600** and be transmitted to the program to the computer system **2667** by using the disc drive **2668**.

The program that executes at least one of a video encoding method and a video decoding method according to an exemplary embodiment may be stored not only in the disc **2600** illustrated in FIG. **26**A or **26**B but also in a memory card, a ROM cassette, or a solid state drive (SSD).

A system to which the video encoding method and a video decoding method described above are applied will be described below.

FIG. **27** illustrates an entire structure of a content supply system **2700** that provides content distribution service. A service area of a communication system is divided into predetermined-sized cells, and wireless base stations **2770**, **2780**, **2790**, and **2700** are installed in these cells, respectively.

The content supply system **2700** includes a plurality of independent devices. For example, the plurality of independent devices, such as a computer **2771**, a personal digital assistant (PDA) **2781**, a video camera **2791**, and a mobile phone **2796**, are connected to the Internet **2710** via an internet service provider **2720**, a communication network **2740**, and the wireless base stations **2770**, **2780**, **2790**, and **2795**.

However, the content supply system **2700** is not limited to as illustrated in FIG. **26**, and devices may be selectively connected thereto. The plurality of independent devices may be directly connected to the communication network **2740**, not via the wireless base stations **2770**, **2780**, **2790**, and **2795**.

The video camera **2791** is an imaging device, e.g., a digital video camera, which is capable of capturing video images. The mobile phone **2796** may employ at least one communication method from among various protocols, e.g., Personal Digital Communications (PDC), code division multiple access (CDMA), wideband-code division multiple access (W-CDMA), the Global System for Mobile Communications (GSM), and the Personal Handyphone System (PHS).

The video camera **2791** may be connected to a streaming server **2730** via the wireless base station **2790** and the communication network **2740**. The streaming server **2730** allows content received from a user via the video camera **2791** to be

streaming-transmitted via a real-time broadcast. The content received from the video camera **2791** may be encoded using the video camera **2791** or the streaming server **2730**. Video data captured by the video camera **2791** may be transmitted to the streaming server **2730** via the computer **2771**.

Video data captured by a camera **2791** may also be transmitted to the streaming server **2730** via the computer **2771**. The camera **2772** is an imaging device capable of capturing both still images and video images, similar to a digital camera. The video data captured by the camera **2772** may be encoded using the camera **2772** or the computer **2771**. Software that performs encoding and decoding video may be stored in a computer readable recording medium, e.g., a CD-ROM disc, a floppy disc, a hard disc drive, an SSD, or a memory card, which may be accessible by the computer **2771**.

If video data is captured by a camera built in the mobile phone **2796**, the video data may be received from the mobile phone **2796**.

The video data may also be encoded by a large scale integrated circuit (LSI) system installed in the video camera **2791**, the mobile phone **2796**, or the camera **2772**.

According to an exemplary embodiment, the content supply system **2700** may encode content data recorded by a user using the video camera **2791**, the camera **2772**, the mobile phone **2796**, or another imaging device, e.g., content recorded during a concert, and transmit the encoded content data to the streaming server **2730**. The streaming server **2730** may streaming-transmit the encoded content data to other clients that request the content data.

The clients are devices capable of decoding the encoded content data, e.g., the computer **2771**, the PDA **1220**, the video camera **2791**, or the mobile phone **2796**. Thus, the content supply system **2700** allows the clients to receive and reproduce the encoded content data. Also, the content supply system **2700** allows the clients to receive the encoded content data and decode and reproduce the encoded content data in real time, thereby enabling personal broadcasting.

Encoding and decoding operations of the plurality of independent devices included in the content supply system **2700** may be similar to those of a video encoding apparatus and a video decoding apparatus according to an exemplary embodiment.

The mobile phone **2796** included in the content supply system **2700** according to an exemplary embodiment will now be described in more detail with reference to FIGS. **28** and **29**.

FIG. **28** illustrates an external structure of a mobile phone **2796** to which a video encoding method and a video decoding method are applied, according to an exemplary embodiment. The mobile phone **2796** may be a smart phone, the functions of which are not limited and a large part of the functions of which may be changed or expanded.

The mobile phone **2796** includes an internal antenna **2851** via which a radio-frequency (RF) signal may be exchanged with the wireless base station **2795** of FIG. **27**, and includes a display screen **2852** for displaying images captured by a camera **2853** or images that are received via the antenna **2851** and decoded, e.g., a liquid crystal display (LCD) or an organic light-emitting diodes (OLED) screen. The smart phone **2796** includes an operation panel **2854** including a control button and a touch panel. If the display screen **2852** is a touch screen, the operation panel **2854** further includes a touch sensing panel of the display screen **2852**. The smart phone **2796** includes a speaker **2858** for outputting voice and sound or another type sound output unit, and a microphone **2855** for inputting voice and sound or another type sound input unit. The smart phone **2796** further includes the camera **2853**, such as a charge-coupled device (CCD) camera, to capture video and still images. The smart phone **2796** may further include a storage medium **2857** for storing encoded/decoded data, e.g., video or still images captured by the camera **2853**, received via email, or obtained according to another method; and a slot **2856** via which the storage medium **2857** is loaded into the mobile phone **1250**. The storage medium **2857** may be a flash memory, e.g., a secure digital (SD) card or an electrically erasable and programmable read only memory (EEPROM) included in a plastic case.

FIG. **29** illustrates an internal structure of the mobile phone **2796**, according to an exemplary embodiment. To systemically control parts of the mobile phone **2796** including the display screen **2852** and the operation panel **2854**, a power supply circuit **2970**, an operation input controller **2964**, an image encoding unit **2972** (e.g., an image encoder), a camera interface **2963**, an LCD controller **2962**, an image decoding unit **2669** (e.g., an image decoder), a multiplexer/demultiplexer **2968**, a recording/reading unit **2967** (e.g., a recorder/reader), a modulation/demodulation unit **2966** (e.g., a modulator/demodulator), and a sound processor **2965** are connected to a central controller **2971** via a synchronization bus **2973**.

If a user operates a power button and sets from a 'power off' state to a power on' state, the power supply circuit **2970** supplies power to all the parts of the mobile phone **2796** from a battery pack, thereby setting the mobile phone **2796** in an operation mode.

The central controller **2971** includes a central processing unit (CPU), a ROM, and a random access memory (RAM).

While the mobile phone **2796** transmits communication data to the outside, a digital signal is generated in the mobile phone **2796** under control of the central controller. For example, the sound processor **2965** may generate a digital sound signal, the image encoding unit **2972** may generate a digital image signal, and text data of a message may be generated via the operation panel **2854** and the operation input controller **2964**. When a digital signal is delivered to the modulation/demodulation unit **2966** under control of the central controller **2971**, the modulation/demodulation unit **2966** modules a frequency band of the digital signal, and a communication circuit **2961** performs digital-to-analog conversion (DAC) and frequency conversion on the frequency band-modulated digital signal. A transmission signal output from the communication circuit **2961** may be transmitted to a voice communication base station or the wireless base station **2795** via the antenna **2851**.

For example, when the mobile phone **2796** is in a conversation mode, a sound signal obtained via the microphone **2855** is transformed into a digital sound signal by the sound processor **2965**, under control of the central controller **2971**. The digital sound signal may be transformed into a transformation signal via the modulation/demodulation unit **2966** and the communication circuit **2961**, and may be transmitted via the antenna **2951**.

When a text message, e.g., email, is transmitted in a data communication mode, text data of the text message is input via the operation panel **2854** and is transmitted to the central controller **2961** via the operation input controller **2964**. Under control of the central controller **2961**, the text data is transformed into a transmission signal via the modulation/demodulation unit **2966** and the communication circuit **2961** and is transmitted to the wireless base station **2795** via the antenna **2851**.

To transmit image data in the data communication mode, image data captured by the camera **2853** is provided to the

image encoding unit **2972** via the camera interface **2963**. The captured image data may be directly displayed on the display screen **2852** via the camera interface **2963** and the LCD controller **2962**.

A structure of the image encoding unit **2972** may correspond to that of the video encoding apparatus **1300** described above. The image encoding unit **2972** may transform the image data received from the camera **2853** into compressively encoded image data according to a video encoding method employed by the video encoding apparatus **1300** or the image encoder **1600** described above, and then output the encoded image data to the multiplexer/demultiplexer **2968**. During a recording operation of the camera **2853**, a sound signal obtained by the microphone **2855** of the mobile phone **2796** may be transformed into digital sound data via the sound processor **2965**, and the digital sound data may be delivered to the multiplexer/demultiplexer **2968**.

The multiplexer/demultiplexer **2968** multiplexes the encoded image data received from the image encoding unit **2972**, together with the sound data received from the sound processor **2965**. A result of multiplexing the data may be transformed into a transmission signal via the modulation/demodulation unit **2966** and the communication circuit **2961**, and may then be transmitted via the antenna **2851**.

While the mobile phone **2796** receives communication data from the outside, frequency recovery and ADC are performed on a signal received via the antenna **2851** to transform the signal into a digital signal. The modulation/demodulation unit **2966** modulates a frequency band of the digital signal. The frequency-band modulated digital signal is transmitted to the video decoding unit **2969**, the sound processor **2965**, or the LCD controller **2962**, according to the type of the digital signal.

In the conversation mode, the mobile phone **2796** amplifies a signal received via the antenna **2851**, and obtains a digital sound signal by performing frequency conversion and ADC on the amplified signal. A received digital sound signal is transformed into an analog sound signal via the modulation/demodulation unit **2966** and the sound processor **2965**, and the analog sound signal is output via the speaker **2858**, under control of the central controller **2971**.

When in the data communication mode, data of a video file accessed at an Internet website is received, a signal received from wireless base station **2795** via the antenna **2851** is output as multiplexed data via the modulation/demodulation unit **2966**, and the multiplexed data is transmitted to the multiplexer/demultiplexer **2968**.

To decode the multiplexed data received via the antenna **2851**, the multiplexer/demultiplexer **2968** demultiplexes the multiplexed data into an encoded video data stream and an encoded audio data stream. Via the synchronization bus **2973**, the encoded video data stream and the encoded audio data stream are provided to the video decoding unit **2969** and the sound processor **2965**, respectively.

A structure of the image decoding unit **2969** may correspond to that of the video decoding apparatus **1400** described above. The image decoding unit **2969** may decode the encoded video data to obtain restored video data and provide the restored video data to the display screen **2952** via the LCD controller **2962**, according to a video decoding method employed by the video decoding apparatus **1400** or the image decoder **1700** described above.

Thus, the data of the video file accessed at the Internet website may be displayed on the display screen **2852**. At the same time, the sound processor **2965** may transform audio data into an analog sound signal, and provide the analog sound signal to the speaker **2858**. Thus, audio data contained in the video file accessed at the Internet website may also be reproduced via the speaker **2858**.

The mobile phone **2796** or another type of communication terminal may be a transceiving terminal including both a video encoding apparatus and a video decoding apparatus according to an exemplary embodiment, may be a transceiving terminal including only the video encoding apparatus, or may be a transceiving terminal including only the video decoding apparatus.

A communication system according to an exemplary embodiment is not limited to the communication system described above with reference to FIG. **27**. For example, FIG. **30** illustrates a digital broadcasting system employing a communication system, according to an exemplary embodiment. The digital broadcasting system of FIG. **30** may receive a digital broadcast transmitted via a satellite or a terrestrial network by using a video encoding apparatus and a video decoding apparatus according to an exemplary embodiment.

Specifically, a broadcasting station **3089** transmits a video data stream to a communication satellite or a broadcasting satellite **3090** by using electronic waves. The broadcasting satellite **3090** transmits a broadcast signal, and the broadcast signal is transmitted to a satellite broadcast receiver via a household antenna **3086**. In every house, an encoded video stream may be decoded and reproduced by a TV receiver **3081**, a set-top box **3087**, or another device.

When a video decoding apparatus according to an exemplary embodiment is included in a reproducing apparatus **3083**, the reproducing apparatus **3083** may parse and decode an encoded video stream recorded on a storage medium **3082**, such as a disc or a memory card to restore the original video signal. Thus, the restored video signal may be reproduced, for example, on a monitor **3084**.

In the antenna **3086** for a satellite/terrestrial broadcast or the set-top box **3087** connected to a cable antenna **3085** for receiving a cable television (TV) programs, a video decoding apparatus according to an exemplary embodiment may be installed. Data output from the set-top box **3087** may also be reproduced on a TV monitor **3088**.

As another example, a video decoding apparatus according to an exemplary embodiment may be installed in the TV receiver **3081** instead of the set-top box **3087**.

An automobile **3092** including an appropriate antenna **3091** may receive a signal transmitted from the satellite **3090** or the wireless base station **2770** of FIG. **26**. A decoded video may be reproduced on a display screen of an automobile navigation system **3093** built in the automobile **3092**.

A video signal may be encoded by a video encoding apparatus according to an exemplary embodiment and may then be stored in a storage medium. Specifically, an image signal may be stored in a DVD disc **3096** by a DVD recorder or may be stored in a hard disc by a hard disc recorder **3095**. As another example, the video signal may be stored in an SD card **3097**. If the hard disc recorder **3095** includes a video decoding apparatus according to an exemplary embodiment, a video signal recorded on the DVD disc **3096**, the SD card **3097**, or another storage medium may be reproduced on the TV monitor **3088**.

The automobile navigation system **3093** may not include the camera **2853**, the camera interface **2963**, and the image encoding unit **2972** of FIG. **29**. For example, the computer **2771** and the TV receiver **3081** may not be included in the camera **2853**, the camera interface **2963**, and the image encoding unit **2972** of FIG. **29**.

FIG. **31** illustrates a network structure of a cloud computing system using a video encoding apparatus and a video decoding apparatus, according to an exemplary embodiment.

The cloud computing system may include a cloud computing server **3100**, a user database (DB) **3110**, a plurality of computing resources **3120**, and a user terminal.

The cloud computing system provides an on-demand outsourcing service of the plurality of computing resources **3120** via an information communication network, e.g., the Internet, in response to a request from the user terminal. Under a cloud computing environment, a service provider provides users with desired services by combining computing resources at data centers located at physically different locations by using virtualization technology. A service user does not have to install computing resources, e.g., an application, a storage, an operating system (OS), and security, into his/her own terminal in order to use them, but may select and use desired services from among services in a virtual space generated through the virtualization technology, at a desired point of time.

A user terminal of a specified service user is connected to the cloud computing server **3110** via an information communication network including the Internet and a mobile telecommunication network. User terminals may be provided cloud computing services, and particularly motion picture reproduction services, from the cloud computing server **3110**. The user terminals may be various types of electronic devices capable of being connected to the Internet, e.g., a desk-top PC **3130**, a smart TV **3140**, a smart phone **3150**, a notebook computer **3160**, a portable multimedia player (PMP) **3170**, a tablet PC **3180**, and the like.

The cloud computing server **3110** may combine the plurality of computing resources **3120** distributed in a cloud network and provide user terminals with a result of the combining. The plurality of computing resources **3120** may include various data services, and may include data uploaded from user terminals. As described above, the cloud computing server **3110** may provide user terminals with desired services by combining motion picture database distributed in different regions according to the virtualization technology.

User information about users who has subscribed to a cloud computing service is stored in the user DB **3110**. The user information may include logging information, addresses, names, and personal credit information of the users. The user information may further include indexes of motion pictures. Here, the indexes may include a list of motion pictures that have already been reproduced, a list of motion pictures that are being reproduced, a pausing point of a motion picture that was being reproduced, and the like.

Information about a motion picture stored in the user DB **3110** may be shared between user devices. For example, when a motion picture service is provided to the notebook computer **3160** in response to a request from the notebook computer **1460**, a reproduction history of the motion picture service is stored in the user DB **3110**. When a request to reproduce this motion picture service is received from the smart phone **3150**, the cloud computing server **3110** searches for and reproduces this motion picture service, based on the user DB **1410**. When the smart phone **3150** receives a motion picture data stream from the cloud computing server **3110**, a process of reproducing video by decoding the motion picture data stream is similar to an operation of the mobile phone **3150** described above with reference to FIG. **29**.

The cloud computing server **3110** may refer to a reproduction history of a desired motion picture service, stored in the user DB **3110**. For example, the cloud computing server **3110** receives a request to reproduce a motion picture stored in the user DB **3110**, from a user terminal. If this motion picture was being reproduced, then a method of streaming this motion picture, performed by the cloud computing server **3110** may vary according to the request from the user terminal, i.e., according to whether the motion picture will be reproduced, starting from a start thereof or a pausing point thereof. For example, if the user terminal requests to reproduce the motion picture, starting from the start thereof, the cloud computing server **3110** streaming-transmits the motion picture starting from a first frame thereof to the user terminal. If the user terminal requests to reproduce the motion picture, starting from the pausing point thereof, the cloud computing server **3110** streaming-transmits the motion picture starting from a frame corresponding to the pausing point, to the user terminal.

In this case, the user terminal may include a video decoding apparatus as described above with reference to FIGS. **1** to **25**. As another example, the user terminal may include a video encoding apparatus as described above with reference to FIGS. **1** to **25**. Alternatively, the user terminal may include both the video decoding apparatus and the video encoding apparatus as described above with reference to FIGS. **1** to **25**.

Various applications of a video encoding method, a video decoding method, a video encoding apparatus, and a video decoding apparatus according to various exemplary embodiments described above with reference to FIGS. **1** to **25** have been described above with reference to FIGS. **26**A to **31**. However, methods of storing the video encoding method and the video decoding method in a storage medium or methods of including the video encoding apparatus and the video decoding apparatus in a device according to various exemplary embodiments, are not limited to the embodiments described above with reference to FIGS. **26**A to **31**.

One of ordinary skill in the art would understand the block diagrams disclosed in the present disclosure as conceptual diagrams of circuits for realizing the principles of the inventive concept. Similarly, it would be apparent to those of ordinary skill in the art that arbitrary flow charts, flow diagrams, state transition diagram, pseudo code, and the like denote various processes that may be substantially stored in a computer readable recording medium and that may be performed by a computer or a processor, regardless of whether the computer or the processor are explicitly illustrated or not. Thus, the exemplary embodiments described above may be embodied as a computer program. The computer program may be stored in a computer readable recording medium, and executed using a general digital computer. Examples of the computer readable medium are a magnetic recording medium (a ROM, a floppy disc, a hard disc, etc.), and an optical recording medium (a CD-ROM, a DVD, etc.).

The functions of various elements illustrated in the drawings may be related to appropriate software, and be provided via not only hardware capable of executing the software but also exclusive hardware. These functions may also be provided via a single exclusive processor, a single shared processor, or a plurality of individual processors, some of which may be shared. Also, explicit use of the term 'processor' or 'controller' is not limited to exclusively using hardware capable of executing software, and may implicitly include a digital signal processor (DSP) hardware, and a read-only memory (ROM), a random access memory (RAM), or a non-volatile storage medium for storing software.

In the claims of the present specification, an element suggested as means for performing a specific operation cover any of arbitrary methods of performing the specific operation. Example of this element may include a combination of circuit elements capable of performing the specific operation, or software having an arbitrary form, e.g., firmware or microcode, which is combined with an appropriate circuit for executing software for performing the specific operation.

In the present disclosure, the expression 'an embodiment' of the principles of the inventive concept and various medications to this expression mean that specific features, structure, and characteristics related to this exemplary embodiment are included in at least one exemplary embodiment of the principles of the inventive concept. Thus, the expression 'an embodiment' and arbitrary other modifications thereof disclosed in the present disclosure do not always indicate the same embodiment.

In the present disclosure, the expression 'at least one of' of 'at least one of A and B' is used to inclusively mean that only the first option (A) is selected, only the second option (B) is selected, or both the first and second operations (A and B) are selected. In addition, the expression 'at least one of A, B, and C' is used to inclusively mean that only the first option (A) is selected, only the second option (B) is selected, only the third option (C) is selected, only the first and second options (A and B) are selected, only the second and third options (B and C) are selected, only the first and third (A and C) are selected or all the three options (A, B, and C) are selected. When more than three items are listed related to this expression, it would be apparent to those of ordinary skill in the art.

While the exemplary embodiments have been particularly shown and described with reference to the drawings, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the inventive concept as defined by the appended claims. The exemplary embodiments should be considered in descriptive sense only and not for purposes of limitation. Therefore, the scope of the inventive concept is defined not by the detailed description but by the appended claims, and all differences within the scope will be construed as being included in the inventive concept.

The invention claimed is:

1. A method of encoding a depth map of multi-view video data, the method comprising:

obtaining a multi-view color video frame and a depth map frame corresponding to the multi-view color video frame;

prediction-encoding and restoring the obtained multi-view color video frame;

splitting a block of the restored multi-view color video frame into at least one partition based on a pixel value of the block of the restored multi-view color video frame;

obtaining a parameter indicating a correlation between each of block partitions of the multi-view color video frame and each of block partitions of the depth map frame by using peripheral pixel values of the block partitions of the multi-view color video frame and peripheral pixel values of the block partitions of the depth map frame corresponding to the block partitions of the multi-view color video frame with respect to each of the block partitions of the restored multi-view color video frame; and

obtaining prediction values of the corresponding block partitions of the depth map frame from the block partitions of the restored multi-view color video frame by using the obtained parameter.

2. The method of claim **1**, wherein the prediction-encoding of the multi-view color video frame comprises:

determining coding units having a tree structure including coding units of a coded depth from among hierarchical coding units corresponding to depths, for each of at least one maximum coding unit that is split from the multi-view color video frame;

determining partitions for prediction-encoding each of the coding units corresponding to the coded depth; and

determining transformation units having a tree structure by performing transformation based on hierarchical transformation units,

wherein the depths each denote a number of times the at least one maximum coding unit is spatially split.

3. The method of claim **1**, wherein the obtaining of the parameter comprises determining the parameter so that differences between the peripheral pixel values of the block partitions of the depth map frame obtained from the peripheral pixel values of the block partitions of the multi-view color video frame and original peripheral pixel values of the block partitions of the depth map frame are minimized by using the correlation.

4. The method of claim **3**, wherein the correlation is a linear relationship, and the parameter comprises a weight and an offset value defining the linear relationship between the peripheral pixel values of the block partitions of the multi-view color video frame and the corresponding peripheral pixel values of the block partitions of the depth map frame.

5. The method of claim **4**, wherein, if the peripheral pixel values of the block partitions of the multi-view color video frame is Rec_Y', prediction values of the corresponding peripheral pixel values of the block partitions of the depth map frame is Pred_D, the weight is a, and the offset value is b, the correlation is defined as an equation: Pred_D=a*Rec_Y'+b.

6. The method of claim **1**, wherein the obtaining prediction values of the corresponding block partitions of the depth map frame comprises:

obtaining the prediction values of the corresponding block partitions of the depth map frame by using block partitions of a restored multi-view color video frame having different color components; and

comparing costs of the prediction values obtained from the block partitions of the restored multi-view color video frame having different color components and determining block partitions of a multi-view color video frame to be used to predict the block partitions of the depth map frame.

7. An apparatus for encoding a depth map of multi-view video data, the apparatus comprising:

an image obtainer which is configured to obtain a multi-view color video frame and a depth map frame corresponding to the multi-view color video frame;

a color video frame encoder which is configured to prediction-encode the obtained multi-view color video frame;

a restorer which is configured to restore the encoded color video frame;

a splitter which is configured to split a block of the restored multi-view color video frame into at least one partition based on a pixel value of the block of the restored multi-view color video frame;

a correlation parameter obtainer which is configured to obtain a parameter indicating a correlation between each of block partitions of the multi-view color video frame and each of block partitions of the depth map frame by using peripheral pixel values of the block partitions of the multi-view color video frame and peripheral pixel values of the block partitions of the depth map frame corresponding to the block partitions of the multi-view color video frame with respect to each of the block partitions of the restored multi-view color video frame; and

a depth map frame predictor which is configured to obtain prediction values of the corresponding block partitions of the depth map frame from the block partitions of the restored multi-view color video frame by using the obtained parameter.

8. A method of decoding a depth map of multi-view video data, the method comprising:

receiving a bitstream obtained by encoding a multi-view color video frame and a depth map frame corresponding to the multi-view color video frame;

decoding the multi-view color video frame;

splitting a block of the decoded multi-view color video frame into at least one partition based on a pixel value of the block of the decoded multi-view color video frame;

obtaining a parameter indicating a correlation between each of block partitions of the multi-view color video frame and each of block partitions of the depth map frame by using peripheral pixel values of the block partitions of the multi-view color video frame and peripheral pixel values of the block partitions of the depth map frame corresponding to the block partitions of the multi-view color video frame with respect to each of the block partitions of the decoded multi-view color video frame; and

obtaining prediction values of the corresponding block partitions of the depth map frame from the block partitions of the decoded multi-view color video frame by using the obtained parameter.

9. The method of claim 8, wherein the decoding of the multi-view color video frame comprises:

obtaining information about a size of each of at least one maximum coding unit that is split from the multi-view color video frame, a depth denoting a number of times the at least one maximum coding unit is spatially split, partitions used to prediction-encode coding units hierarchically configured according to the depth, and transformation units having a hierarchical structure, from the bitstream;

determining coding units having a tree structure including coding units corresponding to a coded depth from among hierarchical coding units corresponding to depths, for each of the at least one maximum coding unit that is split from the multi-view color video frame;

determining partitions for prediction-decoding each of the coding units corresponding to the coded depth; and

determining transformation units having a tree structure, based on the obtained information,

wherein the depths each denote the number of times the at least one maximum coding unit is spatially split.

10. The method of claim 8, wherein the obtaining of the parameter comprises: determining the parameter so that differences between the peripheral pixel values of the block partitions of the depth map frame obtained from the peripheral pixel values of the block partitions of the multi-view color video frame and original peripheral pixel values of the block partitions of the depth map frame are minimized by using the correlation.

11. The method of claim 10, wherein the correlation is a linear relationship, and the parameter comprises a weight and an offset value defining the linear relationship between the peripheral pixel values of the block partitions of the multi-view color video frame and the corresponding peripheral pixel values of the block partitions of the depth map frame.

12. The method of claim 11, wherein, if the peripheral pixel values of the block partitions of the multi-view color video frame is Rec_Y', prediction values of the corresponding peripheral pixel values of the block partitions of the depth map frame is Pred_D, the weight is a, and the offset value is b, the correlation is defined as an equation:

$$Pred_D = a * Rec_Y' + b.$$

13. The method of claim 8, wherein the obtaining prediction values of the corresponding block partitions of the depth map frame comprises:

obtaining the prediction values of the corresponding block partitions of the depth map frame by using block partitions of a restored multi-view color video frame having different color components; and

comparing costs of the prediction values obtained from the block partitions of the restored multi-view color video frame having different color components and determining block partitions of a multi-view color video frame to be used to predict the block partitions of the depth map frame.

14. The method of claim 8, wherein the block of the multi-view color video frame is one of a color video frame block having a same view as the depth map frame block, a color video frame block having a same view scaled to have a same size as that of the depth map frame block, peripheral blocks of a color video frame block having a same view as that of the depth map frame block, peripheral blocks of the color video frame block having a same view scaled to have a same size as that of the depth map frame block, a color video frame block having a different view from that of the depth map frame block determined based on a disparity vector indicating a difference between views of multi-view video, a color video frame block having a different view scaled to have a same size as that of the depth map frame block and determined based on the disparity vector, peripheral blocks of the color video frame block having a different view from that of the depth map frame block determined based on the disparity vector, and peripheral blocks of the color video frame block having a different view scaled to have a same size as that of the depth map frame block and determined based on the disparity vector.

15. An apparatus for decoding a depth map of multi-view video data, the apparatus comprising:

a receiver which is configured to receive a bitstream obtained by encoding a multi-view color video frame and a depth map frame corresponding to the multi-view color video frame;

a color video frame decoder which is configured to decode the encoded multi-view color video frame obtained from the bitstream;

a splitter which is configured to split a block of the decoded multi-view color video frame into at least one partition based on a pixel value of the block of the decoded multi-view color video frame;

a correlation parameter obtainer which is configured to obtain a parameter indicating a correlation between each of block partitions of the multi-view color video frame and each of block partitions of the depth map frame by using peripheral pixel values of the block partitions of the multi-view color video frame and peripheral pixel values of the block partitions of the depth map frame corresponding to the block partitions of the multi-view color video frame with respect to each of the block partitions of the decoded multi-view color video frame; and

a depth map decoder which is configured to obtain prediction values of the corresponding block partitions of the depth map frame from the block partitions of the decoded multi-view color video frame by using the obtained parameter.

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